
Degradation of forest and biodiversity in Sariska National Park, India and the responsible factors

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Abstract: Sariska Tiger Reserve has been in the limelight due to the extinction of its prime species tiger. It is a serious matter of concern to maintain the erstwhile rich biodiversity of the reserve. Due to illegal poaching and extensive pressure from the villagers for grazing and various forest products, man animal conflict has been growing and leading to the degradation of forest and its bio-diversity. Thus, efforts are on through reintroduction of a few tigers in the park from other forest area and gradual relocation of families from the core areas to control the degradation of pristine forest and its bio-diversity along with the improvement of the situation. This paper tries to examine the nature of degradation of forest and bio-diversity of Sariska Tiger Reserve. In addition, the reasons for the degradation have been analysed with the help of collected primary data and available secondary information.

Keywords: degradation of forest; biodiversity; extinction of tiger; Simpson index; forest ecosystem; predator-prey relationship; sustainable forest management; man-animal conflict; wildlife tourism; Sariska Tiger Reserve; STR.

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1 Introduction

Forest has been an integral part of life of the forest dwellers and a key source of their livelihood. Besides providing livelihood to a large number of people in the form of food, timber and non-timber products, it helps to protect watershed by reducing surface run off, check flood, soil erosion, safeguard against drought, atmosphere regulation and to maintain biodiversity (Poffenberger et al., 1996; Sharma, 2006; Olander et al., 2008; Mukhia et al., 2013). Forest biodiversity also provides conditions for the development of tourism in an area and has been associated with the social, economic and cultural life of the forest dwellers. The long associations of grazers/herders/villagers with forest and their low socio-economic profile have in many cases resulted in a higher dependency of villagers on the forest for livelihood than other population groups.

With growing population and trade in wood, illegal trade practice like poaching of wildlife etc., the forests have been endangered. Prime forest reserves in the world, like the Amazon rainforest in Brazil, the Congo Basin forest in Africa and Indonesia Rainforests in South-East Asia have been under severe threat of extinction (World Bank, 1987, 1988; IUCN, 2001). Indiscriminate felling of trees to meet various domestic needs, over-grazing of cattle especially in the common forest, rapid urbanisation, industrialisation and overall population growth are some major factors held responsible for the degradation of forests. Degradation is often demonstrated through reduction in biomass, changes in composition of species and soil degradation leading to further destruction of the critical habitat. It implies loss of important links in the food chain that contributes to various levels of the ecosystem. Whatever be its form, nature of property rights (whether common or private) and the management framework (institutional structure) also play crucial roles in the degradation of forest resources across the nations (Hardin, 1968; Ostrom et al., 1994; Olson, 1998; Buchanan and Yoon, 2000; De, 2006).

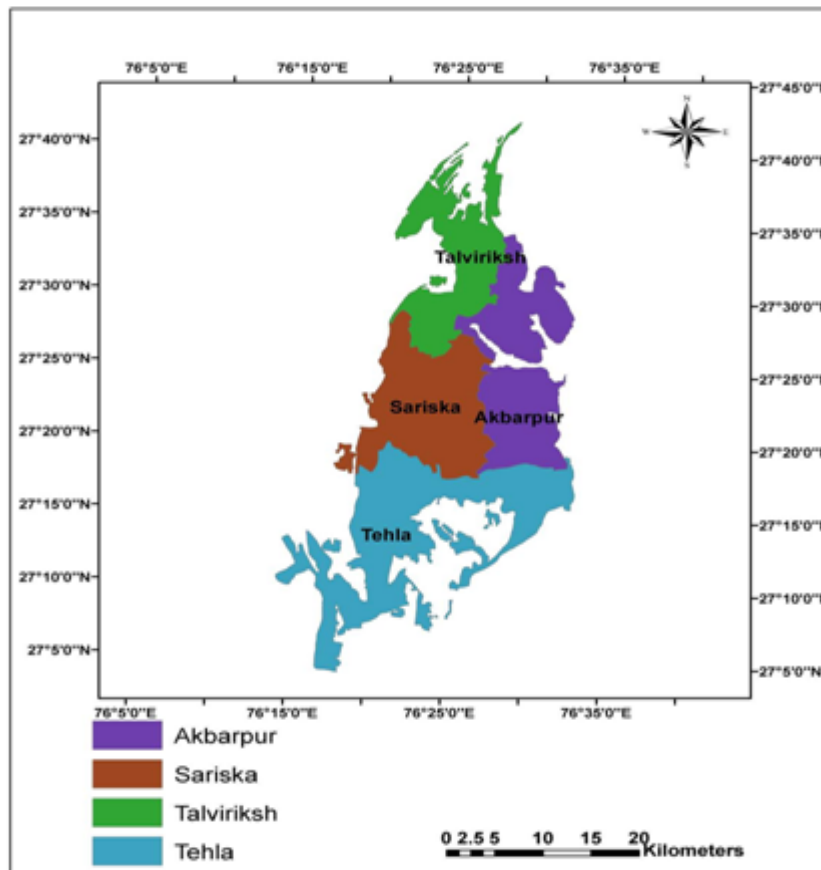
Dependence on forest for fuel wood, fodder, timber and minor forest products have been an accepted way of life for rural populations that account for nearly 74% of India's population (Government of India, 2012). With critical demographic changes, the land-man ratio and per capita forest area have declined rapidly over time. It has been leading to the relentless pressure of encroachment for cultivation, and unsustainable resource extraction and rendering the very resource base unproductive, which in turn resulted in depletion of its biodiversity. Along with these incongruities and aberrations in land use, unsound development strategies have led to increasing threats to biodiversity by way of diversion of forest for agriculture, river valley projects, industries, townships, roads etc (TERI, 1999).

2 Status of forest in Rajasthan and Sariska Tiger Reserve

The state of Rajasthan in India has recorded forests of only 32,639 sq km (9.54% of its geographical area), of which 38.16% is reserved forests, 53.36% is protected and the remaining is un-classified forests (Government of India, 2007, 2011). However, the actual forest (tree) cover, as on December 2008, was only 4.70% of the state's geographical area.¹ In terms of forest canopy density classes, the state has only 72 sq km of very dense forest, 4,448 sq km of moderately dense and 11,567 sq km of open forest (State of the Forest, 2012).

Only 14 sq km of very dense forest has been ascertained in Sariska (Forest Survey of India Report, 2003). Total area of STR is however 866 sq km including 492 sq km of the notified Sariska Wildlife Sanctuary and 374 sq km of adjoining area of Alwar, Rajgarh and Sariska Forest Ranges (Figure 1). The forest of STR falls under group V and VI of Champion and Seth (1968) classification of Tropical Dry Deciduous and Tropical Thorn. Total Reserve Forest area in the sanctuary is 39,705 hectares. While protected forest area in the sanctuary is 9,494.54 hectares. Nestled in the world's oldest mountain ranges, STR, with its repository of dense forest, wide valley and sprawling plateaus, has drawn attention worldwide for the loss of its flagship species and biodiversity, which is one of the prominent examples of human-wildlife conflict under the broad umbrella of economy-environment relationship and development-environment trade-off (Chauhan, 2014).

Figure 1 Range map of STR (see online version for colours)



Source: Ecological studies in Sariska Tiger Reserve, Final Report 2008, Wildlife Institute of India

Forest Survey of India (FSI) under the Project Tiger Directorate (2004) found that, during 1997–2002 (only in five years), overall forest cover in all the existing 28 Tiger Reserves (TR) of the country decreased by 0.31%, of which 0.21% occurred during 1997–2000 and

the rest of 0.10% occurred during 2000–2002. Only five TRs in the country recorded an increase in forest cover during the same period. Field surveys carried out by the authors, reveals a significant decrease in forest cover and density of the STR over the years and that can be easily verified if the available satellite pictures of 2011 are compared with the topography sheets of 1970's. Further, there has been a significant change in biodiversity in the park, which has been a major attraction for large number of tourists.

Forest cover in the outer surround of Tiger Reserves in India shows a decrease of 0.48 % (by 124 Sq km) during 1997 to 2002, of which 0.28% occurred during 1997 to 2000, and the remaining decline of 0.20% occurred during 2000 to 2002. The Outer Surround of STR also recorded a decrease of about 1% during 1997 to 2002. Overall degradation of the forest cover in the outer surrounds exceeded that of the tiger reserves in the country. It provides a warning for the protection of the core reserves from the threat of more encroachment and degradation.

3 The research problem and objective

Villagers in the STR were traditionally a nomadic herder/grazer's tribe, dependent on livestock for milk-production. They were also food gathering and hunting community, such as Bawariyas living in this forest. Their economic activities and survival has been closely linked with the forest and pastoral activities. The present area of Sariska National Park was once a hunting paradise of the Royalty and British Raj during the reign of Maharaja of Alwar since the early 20th century, and was a shooting block for both Royalty and British officials. After independence, shooting was permitted to continue until 1955. It was declared as a Wildlife Reserve on 7th November, 1955 under Rajasthan Wild Animals and Birds Protection Act, 1951 (Management plan, 2000, Sariska). It was however, a paradise for the poachers during the early period of independence and park lost a good number of its rich wildlife.

After the formation of the state in 1947, all forest areas were leased out to the private contractors for manufacturing of charcoal and firewood. Felling of trees continued until 1967, even after the formation of sanctuary, without following conservation practices of forestry. Unrelenting extraction of other forest produces, like fuel wood, foliage, tubers, fruits, etc and grazing activities were continued and control mechanisms remained inadequate.

Unplanned mining of marble, limestone and dolomite at the periphery of the reserve forest had been the other reasons for its degradation and leading to broken periphery. About 500 mines were functional in an around the STR during late 1970s, which were closed down in early 1980s due to the initiative of a local NGO, Tarun Bharat Sangh (TBS) which also started conservation work in the villages since 1985 (Government of Rajasthan, 2000).

Rodgers (1990), Shahabuddin et al. (2004), Government of India (2005) in their studies paid attention primarily to the degradation of Core-I area where proposed national park was carved out. Whereas the other Core areas, II and III, were adjacent to the buffer areas, and thus were accessible to the villagers who lived in the surrounding buffer zone. Thus these areas were also under severe degradation. It has been observed that, not only the core zones but also the buffer, with high anthropogenic interference in the periphery has been subject to irreparable damage. Cattle rearing were still a major

economic activity in the STR and its vicinity, where most of the inhabitants were living in a primitive condition (as shown later from the primary survey).

Therefore, a complex interplay of various factors needs to be examined in order to establish the causes of degradation of habitat of SNP. It may provide some important clues to ascertain the reasons behind the degradation of the park over the years.

This paper examines the nature of degradation of STR and its biodiversity in order to understand the nature and pace of degradation of the park. In addition, the authors tried to examine the relevant reasons for degradation to provide important guidelines for addressing the issues appropriately.

4 Method of analysis and materials used

At first, the nature and extent of degradation of forest and biodiversity of Sariska National Park was analysed. Thereafter, factors responsible for the degradation of forest in and around the reserve were examined². Degradation of forest was examined by using both the available secondary data as well as primary data collected from the villagers through direct interview, using a suitable interview schedule as well as through time-to-time organised focus group discussion. Time series data on area under various categories like dense, open forest etc are not available for the park and thus cannot be used to analyse the changes in area under various categories of forests. Thus, over time quantitative and qualitative changes in forest cover or level of degradation was examined here through the changes in labour and time used for harvesting forest resources for the survival of families³. Degradation first takes place in the nearby surroundings of population settlement and that leads to decline in availability of required materials and quality of grazing field in the neighbourhood. Hence, the changes in distance travelled, time and labour requirement (say, effort) by the villagers for maintaining similar livelihood indicate the extent of degradation.

Degradation of fauna or species' diversity in number and variety was examined directly through the variation in species structure, and indirectly through the decline in interest of the visitors⁴. Change in diversity of species was also examined by the changes in Simpson index of diversity (SI) over time in the park (Simpson, 1949). The index is defined as

$SI = \sum P_i^2$ where P_i represents the proportion of i^{th} species to total number of available species in the reserve in a particular year. Lower the value of this index, higher the diversity and vice versa.

Causes of degradation was examined in terms of rising pressure on the forest for livelihood in the form of growing population, cattle and thus demand for pasture, fodder and fuel wood. In addition, trend of tourists visiting every year is a reflection of pressure on this forest, as well as attraction of nature loving visitors. Growth in tourist arrival was estimated by fitting a log-linear equation of the type $\text{Ln}Y_t = a + b.t$; where Y_t is the number of tourists in the year t and b represents the annual exponential rate of growth. Opinion of the sample tourists, who visited earlier, was also utilised to obtain some idea of the degradation.

Shortcomings in management also have important implications on the degradation of forest and biodiversity. Here, the lacuna on the part of management has been described

based on information collected from the Sariska Authority. Finally, the management policies of relocation vide compensation for the protection of the reserve was compared with the existing earnings from the park to know the inconsistency in relocation policy and failure to achieve sustainable management. The willingness to pay by the tourists was also considered to examine the benefit of preservation and the overall gain as against the loss of livelihood.

Primary data were collected from a random sample drawn from 16 villages, selected by simple random sampling without replacement, from all the 28 villages belonging to different core zones of the park. The whole core area has been officially divided into three zones namely Core-1 (having 11 villages at present with 318 families), Core-2 (having 11 villages with 364 families) and Core-3 (having 6 villages with 52 families) respectively making 734 families in all the core areas. 9, 5 and 2 villages have been chosen from three core areas respectively by simple random sampling without replacement. A total of 294 families from the 16 STR villages (core 1, 2 and 3) were selected as final sample units, and household heads were chosen as the respondents. Here samples are distributed over core-1, core-2 and core-3 in order to have an idea of variation in degradation level in the prime forest area of core-1 and adjacent to buffer area of core-2, and core-3. In addition, the authors tried to understand the dependence of villagers on forest and reasons for it. Also, 23 households out of presently 105 households in the relocated area of Bardodh, Rudh were surveyed in order to examine their comparative socio-economic status with that of their earlier location in Core-1.

Moreover, primary data were also collected from the 305 visiting tourists (to know their willingness to spend for visiting the site) and secondary information on temporal variation in tourist is used in order to understand the pressure on forest from tourism and its contribution towards the change in forest and biodiversity. Information on the villagers' socio-economic conditions, extraction of resources from the park as well as their involvement in cattle grazing and harvesting of forest resources (timber and non-timber) in the SNP was collected by direct interviews using a pretested schedule.

5 Observation and analysis

Density of forests in Sariska has been found to decrease significantly over the years. Though time series data on changes in crown density, forest cover are not available, a comparison of the topography image of the forest in 1969⁵ (Figure 2) and satellite imagery of the same in 2010 (Figure 3) provides an estimate of degradation of forest cover in the park during 1969 to 2010. An increase in area under scrubland (open forest) over the erstwhile dense forest area has been highlighted. The comparative picture also signifies an increase in fallow/barren land in the park.

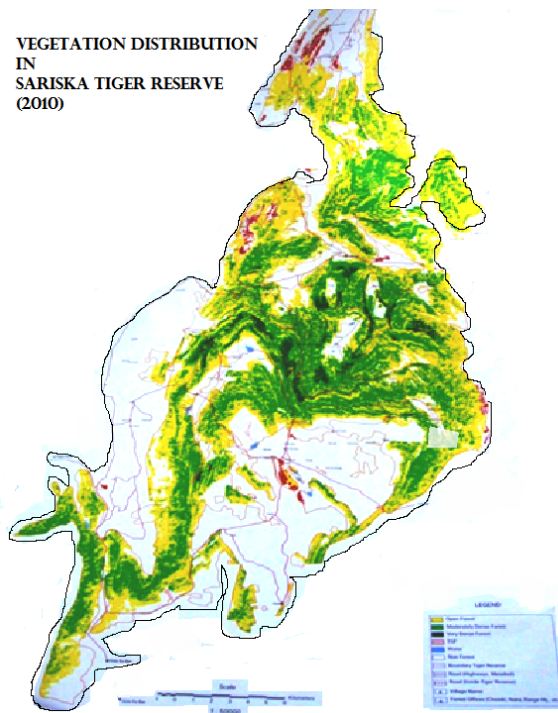
Figures 2 and 3 however do not provide a clear idea of the extent of degradation. In the absence of time series data on changes in density of forest, an alternative method is applied to examine the extent of degradation of forest across the zones. Here, the zone-wise changes in time and labour spent (effort) for the purpose and distance travelled along with the changes in grazing of cattle and its productivity was analysed to understand the nature and extent of degradation of the park during last three decades and its spatial pattern.

Figure 2 Forest cover map of STR, 1969 (see online version for colours)



Source: Forest Survey of India (1969)

Figure 3 Forest cover map of STR, 2010 (see online version for colours)



Source: Forest Survey of India (2010)

5.1 Socio-economic status of the villagers of core areas of STR

As mentioned above, the inhabitants of the STR mostly follow the pastoral activities for their survival. This has been due to the lack alternative opportunities and their inability to avail alternative occupation for their interior location from the main town and for their poor educational status as well as capacity to undertake skilled activities. Distance of core area villages from the nearest town varies from 3 to 25 KM. Also, the primary as well as secondary schools and primary health centres are located far away from various villages of the core areas. The distance ranges from 3 to 28 K.M. Moreover, they are not allowed to use forest patches for any kind of agricultural operation and most of them do not own any agricultural land. Some villages of core-2 and 3 are nearby the business centres, educational institutions or health centres. The socio-economic status of the surveyed families is presented in Table 1 briefly.

Table 1 Socio-economic characteristics of the households in the surveyed villages of core zones

Zone	Village	Families living at present	Family size	Sex ratio	Crude literacy rate	Per capita annual income (Rs)	Per capita annual earing from Milk and Live-stock (Rs)	Owning of cattle per capita
Core-1	Umri, Deori	25	6.0	813	7.7	30,609.12	30,609.12	4.9
	Kraska	40	5.0	745	14.0	20,685.36	20,685.37	2.8
	Rotkayala	47	7.0	727	9.8	25,989.96	25,989.98	3.3
	Sukola	42	8.0	949	13.2	20,243.04	20,242.99	5.0
	Kankwari	36	7.0	772	12.0	24,254.4	24,254.46	3.9
	Haripura	65	5.0	933	36.2	18,779.28	18,779.31	2.2
	Leelunda	20	7.0	726	8.9	11,673.12	11,673.06	1.4
	Dabli	43	7.0	849	14.0	38,690.28	38,690.24	6.4
	Raikamala	105	7.0	926	00	33,825.6	33,825.63	6.6
<i>Subtotal/Avg</i>		<i>423</i>	<i>6.56</i>	<i>805</i>	<i>12.7</i>	<i>24,684.48</i>	<i>24,684.44</i>	<i>3.8</i>
Core-2	Raika	25	8.0	757	40.7	22,799.4	20,666.67	2.7
	Panidhal	9	6.0	710	00	24,935.88	24,483.02	4.5
	Kali Khol	18	8.0	817	20.8	19,171.8	19,171.81	5.4
	Kalachara	61	6.0	770	15.0	23,328.48	19,889.56	2.8
	Bairawas	103	7.0	548	28.3	25,307.64	19,837.17	4.0
<i>Subtotal/Avg</i>		<i>216</i>	<i>7.0</i>	<i>735</i>	<i>21.7</i>	<i>22,668.48</i>	<i>20,287.05</i>	<i>3.9</i>
Core-3	Kanyawas	30	7.0	800	30.0	27,803.16	25,136.45	3.3
	Mandalwas	65	8.0	672	11.0	28,602.72	20,131.96	2.4
<i>Subtotal/Avg</i>		<i>95</i>	<i>7.5</i>	<i>752</i>	<i>23.5</i>	<i>28,092.48</i>	<i>23,325.12</i>	<i>3.0</i>
<i>Over All</i>		<i>629</i>	<i>7.02</i>	<i>776</i>	<i>16.9</i>	<i>24,564.36</i>	<i>23,212.22</i>	<i>3.7</i>

Source: Calculated by authors from the field survey data of STR during 2010–2011

Most of the people living in various core areas, belong to the Gujjar communities and earn their livelihood from the pastoral activities, excepting a few of core 2 and 3, adjacent to Buffer, who earn a small portion of income from agriculture or other activities, available in the nearby towns. Despite poor literacy in the whole area, people of core-1 are comparatively more illiterate than those of other cores. Per capita holding of cattle is however more or less same across the cores. But the annual earning from forest directly or indirectly is marginally higher in core-1 where the degradation is relatively low as compared to the semi-buffer other core areas. From the annual per capita earning, it appears that the people belonging to core areas of Sariska are above poverty line. But, it may be noted that the values of earning from various forest resources are computed by using the equivalent market prices, despite most of the wood and non-wood forest products are used at home for sustenance and only a little portion of earning comes in monetary form through the sale of milk, milk derivatives and cattle. Thus the livelihood pattern observed from their food intake, occupational pattern, mode of expenditure etc indicates their distressed conditions.

5.2 Changes in efforts and its variation across the core areas for earning livelihood from the forest

As per the response of the villagers, in earlier days of 1980–1981, most of the forest dwellers used to get their required forest products in their close vicinity, within a 1 Km radius of their living places, across all the villages (Table 2). With the passage of time, due to population growth and degradation of forest in the adjacent areas they have to travel far, in order to graze their cattle and to collect such products. Despite prevalent scarcities in the neighbourhood and growing requirements of population, the poor populace has not adopted the alternative opportunities significantly. Until now, they are dependent on those forest products for their unchanged livelihood pattern (food, cooking, housing, cattle rearing etc). Thus, now they have to travel daily three to four kilometres from their residences for the collection of forest products and grazing. Only in core-2 and core-3, which are closer to buffer areas, villagers along with the aforesaid forest-based activities have adopted limited other occupations like agricultural labour; MGNREGA works, offered to them in the outskirts villages.

From each family on an average 6 to 8 labour hours used to be spent daily for the collection of minor timber and non-timber forest products during 1980s. This information was gathered from the elderly family members in case the main respondents failed to provide them. On an average, daily labour time used for the same purpose increased to 30–32 hours during 2010–2011. It was also an indication of increasing use of labourers from each family and for longer hours in their forest-based activities. Increase in distance travelled and time used for the collection of forest products for survival however varied across the zones depending upon the extent of degradation of forest and pasture in the vicinity.

Table 2 Variation and average distance travelled by an average household for grazing and fodder collection in the surveyed villages of core zones

Zone	Village	Dist. travelled (km)		Labour hour/day		Fuel wood (kg)/day	Grass/tree fodder (kg)/day	Timber pole (per-yr)	Thatching grass (per-yr)	Change in percentage	
		1980-1981	2010-2011	1980-1981	2010-2011						Distance travelled
Core-1	Umri, Deori	1.00	3.00	7.00	29.86	89.05	73.10	48.33	53.33	200.00	326.53
	Kraska	1.00	2.91	7.00	22.57	87.71	75.29	43.86	49.00	191.43	222.45
	Rotkayala	1.00	3.00	6.00	36.05	106.32	93.16	61.58	64.74	200.00	500.88
	Sukola	1.00	3.67	6.00	44.00	124.44	111.11	74.33	85.00	266.67	633.33
	Kankwari	1.00	3.00	5.00	33.29	105.00	83.57	60.71	70.24	200.00	565.71
	Haripura	1.00	2.82	5.00	24.27	80.45	74.77	54.77	59.32	181.82	385.45
	Leelunda	1.00	4.00	7.00	31.60	53.25	45.75	40.00	45.00	300.00	351.43
	Dabli	1.00	3.96	6.00	34.87	92.61	74.13	49.78	53.91	295.65	481.16
	Raikamala	1.00	5.13	5.00	32.88	70.63	68.13	40.63	47.50	412.50	557.50
	<i>Average</i>	<i>1.00</i>	<i>3.50</i>	<i>6.00</i>	<i>32.15</i>	<i>89.94</i>	<i>77.67</i>	<i>52.67</i>	<i>58.67</i>	<i>249.79</i>	<i>435.90</i>
Core-2	Raika	1.00	3.80	8.00	24.00	79.00	65.00	40.00	44.00	280.00	200.00
	Pandhal	1.00	3.89	8.00	26.44	63.00	59.00	38.00	41.00	288.89	230.56
	Kali Khol	1.00	4.94	8.00	24.00	60.00	51.00	38.00	44.00	394.44	200.00
	Kalachara	1.00	4.67	8.00	22.86	63.00	47.00	36.00	41.00	366.67	185.71
	Bairawas	1.00	4.25	7.00	20.00	59	53.00	42.00	46.00	325.00	185.71
<i>Average</i>	<i>1.00</i>	<i>4.31</i>	<i>8.00</i>	<i>23.46</i>	<i>67.46</i>	<i>58.44</i>	<i>38.59</i>	<i>42.72</i>	<i>331.00</i>	<i>193.25</i>	
Core-3	Kanyawas	1.00	3.56	8.00	20.00	70.00	70.00	35.00	44.00	256.00	150.00
	Mandalwas	1.00	4.00	8.00	20.00	60.00	54.00	39.00	43.00	300.00	150.00
	<i>Average</i>	<i>1.00</i>	<i>3.78</i>	<i>8.00</i>	<i>20.00</i>	<i>65.00</i>	<i>61.88</i>	<i>37.08</i>	<i>43.36</i>	<i>278.00</i>	<i>150.00</i>
<i>Over all</i>	<i>1.00</i>	<i>3.79</i>	<i>7.00</i>	<i>25.20</i>	<i>74.00</i>	<i>66.00</i>	<i>43.00</i>	<i>48.00</i>	<i>278.69</i>	<i>260.00</i>	

Source: Calculated from Field Survey Data of STR during 2010-2011

In the core-1, distance travelled and person-hours required for collecting fodder and fuel wood increased by 249.79% and 435.90% respectively during past three decades. Considering the earlier vegetation cover, increase in distance covered was comparatively high in core-1. Growth in labour hours required was even significantly higher than the other core areas and after so much of awareness programs, degradation has been continuing. The growth in distance travelled was however lower in core-1 as compared to the other zones. During the same period, distance travelled in core-2 and core-3 for the identical activities has increased by 321.11% and 278%, while labour hour used for the purpose has increased respectively by 303.98% and 327.81%. Though due to relatively more vegetation in core-1, growth of distance travelled has been comparatively lower than that of other two zones the labour hour used has increased at a relatively rapid rate. The primary reason was that the people of core-1 were more dependent on the forest for their livelihood and there has been less surveillance and monitoring by the forest officials and thus led to the longer use of time for extraction and grazing. Hence, more labour time was devoted to collect as much as possible and to feed their larger herd of cattle in order to maintain its productivity. Whereas, the other zones were closer to the buffer zones, where pressure of grazing continued from both inside and outside the reserve over the years and hence degradation has already been widened and people have to travel more. Despite that, the growth in labour hours required was less because of the diversion of activities, though not significantly. Due to the availability of alternative jobs in the surrounding (in agriculture on a small scale due to restrictions by the forest authority) they spend less labour hours for forest resource collection and grazing, and compensate them by purchasing fodders etc as has been clear from Tables 3a and 3b.

Still now, collection of various forest resources by an average family in core-1 is significantly higher than that of core-2 and core-3 (Table-3a and 3b). On an average, a family in core-1 collects fuel-wood 42.36% and 33.32% higher than that of a family of core-2 and core-3 respectively. In case of grass, tree fodder, timber or thatching grass also core-1 families collect significantly more than those of core-2 and core-3. This information supports the argument of more overall dependence of a family in core-1 than that of core-2 and core-3.

Table 3a Comparative difference of Core-1 from Core-2 and Core-3 in terms of collection of some items by an average family (%)

	<i>Fuel wood (kg per day)</i>	<i>Grass/tree fodder (kg per day)</i>	<i>Timber pole (no. per yr)</i>	<i>Thatching grass (kg per yr)</i>
Compared to Core-2	42.36	38.52	38.42	35.00
Compared to Core-3	33.32	32.91	36.49	37.34

Source: Computed by author from primary data collected during 2010–2011

Table 3b Per capita annual value of resource collected and income from all sources in STR

Zone	Population	Avg. fam. member involved	Annual value of resource collected (Rs)							Annual income from all sources (Rs)				
			4	5	6	7	8	9	10	11	12			
			Fuel-wood	Grass/tree fodder	Timber/pole	Thatching grass	Direct forest collection (4 + 5 + 6 + 7)	Milk net	Live stock	Agri.	Off-farm			
Core-1	1,110	5	20,517	17,763	988	37	39,305	3,712	3,209	0	0			
Core-2	569	4	12,945	10,969	643	24	24,581	6,430	2,888	1,086	1,295			
Core-3	268	4	13,272	13,020	604	24	26,920	7,438	2,867	3,825	943			

Source: Computed from the Field Survey 2010–2011

Table 4 Changes in wild animal population during 1987 to 2009 in STR

Species/zoo logical name	No				Change in percentage				
	1972	1988	1999	2009	1972-1988	1988-1999	1999-2009	1988-2009	1972-2009
Tiger/Panthera Tigris	14	45	27	3	221.4	-40.0	-88.9	-93.3	-78.6
Leopard/Panthera Pardus	35	47	55	47	34.3	17.0	-14.5	0.0	34.3
Jungle Cat/Felis Cnaus	NA	749	125	168	NA	-83.3	34.4	-77.6	NA
Caracal/Fellis Caracal	NA	NA	7	NA	NA	NA	NA	NA	NA
Hyena/Hyena Hyena	NA	284	115	296	NA	-59.5	157.4	4.2	NA
Jackal/Canis Aureus	NA	2,264	363	1,521	NA	-84.0	319.0	-32.8	NA
Sambhar/Cervus Unicolor	800	12,336	6,150	7,196	1,442.0	-50.1	17.0	-41.7	799.5
Chital/Axis Axis	540	7,979	3,600	4,021	1,377.6	-54.9	11.7	-49.6	644.6
Neelgai/Boselaphus Tragocamelus	300	11,022	5,200	6,018	3,574.0	-52.8	15.7	-45.4	1,906.0
Chowsinga/Tetracos Quadricomis	30	489	13	NA	1,530.0	-97.3	NA	NA	NA
Chinkara/Gazella Gazella	NA	12	NA	NA	NA	NA	NA	NA	NA
Wild Boar/Sus Scrofa	NA	4,895	3,450	5,033	NA	-29.5	45.9	2.8	NA
Rhesus Monkey/Mecaca Mulatta	NA	6,803	E	P	P	P	P	P	P
Common Langor/Presbyts Entellus	NA	12,797	VC	8,136	NA	NA	NA	-36.4	NA
Indian Porcupine/Hystrix Indica	NA	653	368	512	NA	-43.6	39.1	-21.6	NA
Civet Cat	NA	NA	E	165	NA	NA	NA	NA	NA

Notes: VC = very common; E = present; P = plenty; NA = not available

Source: Management Plan 1978-1979 to 2004-2014, Sariska Tiger Reserve, Govt. of Rajasthan

5.3 *Degradation of biodiversity*

Table 4 revealed that overall density of major wildlife declined especially after 1988. Despite several deficiencies in the method of animal census, (which is clear from the lack of information on various wild animals in the early years), it has improved considerably and now data are available at least up to a level that may help in forming an idea of about its change. The prime species of STR, tiger was increasing from 1972 to 1988 and thereafter started declining rapidly. Despite poaching being banned, due to very high economic value of tiger skin and by-products in the illegal market, poaching of tigers continued and it was reported to have been completely extinct in 2005 (Government of India, 2005). After extensive campaigns, steps have been taken to preserve such an important wild species, and the park has been specifically reserved for it. This has led to the distortion of forest ecosystem and food chain as well. That is why the prey in tiger's food chain say monkey and deer population has increased significantly in the previous decade and it became so much that counting of these species are not carried out at present. Thus, one can call it now, a monkey and deer reserve instead of a tiger reserve.

Further, the other species, like sāmbar, panther, chowsinga have become the second best targets of the poachers due to black marketing of skins and the like. However, the rich biodiversity has been the main attraction of the tourists in the area and tourists visiting the park (as obtained in the primary survey) have also been complaining about the poor maintenance of the park and declining forest patches of popular tourist attractions in core-1.

Tourism in the area has been both cause and effect of degradation of STR. Rising pressure of tourism and its related activities in many cases damage the forest area. STR was once a popular tourist destination. But nature lovers and pilgrimage visitors have significantly damaged the forest. Pilgrimage tourists during their stay inside the park use forest firewood excessively and affected the forest resources and movements of its animals in the past, who were often joined by the poachers. Later on, the degradation of bio-diversity affected inflow of tourists and thus the trend of tourist arrivals over time is an indirect indication of degradation.

Tourist arrival in STR during 2005 to 2008 declined seriously and diverted to other locations, especially the nearby Ranthambhor National Park, a substitute site, which is another popular tourist destination for the tiger trail. Not only tourism, the forest ecosystem of the area has been threatened and that has forced the authority to undertake relocation of tigers from other areas, which has been underway since 2008. Until now, seven tigers have been relocated to this park to protect this prime habitat and maintain food chain and ecosystem of the reserve.

Numbers of prime species like tiger, panther, caracal etc., which are sensitive to the habitat and forest richness, are dwindling in numbers (Table 4). Though some tigers have been relocated after its complete extinction in 2005, the situation is grim and possibility of further degeneration is very high. According to the conservationists (Rodgers, 1990), tigers need better corridors for their movement and breeding. Nevertheless, over the years their movement has been restricted to a limited area within the core-1 and virtually leaving other core areas out of the preview. Shrinking of forest corridors for the fauna is primarily attributed to the degradation of forest and increasing human interference in the reserve. Besides, poaching of tiger in STR has become easy over the years with shrinking tiger corridors and declining crown density that made tigers and other wildlife easy prey to the poachers.

Table 5 Changes in proportion of wild animals to total in STR during 1972–2010 (percentage) and Simpson index

Species/zoo logical name	1972	1975	1977	1987	1988	1989	1991	1992	1993	1994	1995	1997	1999	2002	2003	2004	2007	2009	2010
Tiger/Panthera Tigris	0.81	0.81	0.45	0.07	0.07	0.07	0.08	0.10	0.11	0.11	0.11	0.10	0.10	0.12	0.12	0.05	0.00	0.01	0.01
Leopard/Panthera Pardus	2.04	2.32	0.41	0.07	0.08	0.10	0.12	0.16	0.18	0.20	0.20	0.20	0.21	0.27	0.27	0.12	0.09	0.14	0.16
Jungle Cat/Felis Cnaus	0.00	0.00	0.00	1.22	1.24	0.89	0.70	0.65	0.65	0.44	0.44	0.40	0.47	0.61	0.62	0.62	0.48	0.51	0.46
Caracal/Fellis Caracal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.03	0.04	0.04	0.01	0.00	0.00	0.03
Hyaena/Hyaena Hyena	0.00	0.00	0.00	0.50	0.47	0.69	0.62	0.46	0.46	0.44	0.44	0.33	0.43	0.56	0.58	0.86	0.00	0.89	1.25
Jackal/Canis Aureus	0.00	0.00	0.00	3.67	3.75	5.00	1.31	0.79	0.79	1.11	1.11	1.40	1.36	1.88	1.93	4.67	4.96	4.58	6.34
Sambhar/Cervus Unicolor	46.54	46.40	32.77	22.65	20.43	13.72	20.43	20.90	20.91	21.29	21.32	23.04	23.07	28.03	27.51	18.04	18.18	21.68	27.05
Chital/Axis Axis	31.41	31.32	28.68	11.33	13.22	12.91	12.24	11.61	11.61	12.86	12.88	11.93	13.51	16.77	16.55	10.89	10.55	12.12	18.16
Neelgai/Boselaphus Tragocamelus	17.45	17.40	36.87	17.28	18.26	21.14	16.17	19.05	19.05	19.07	19.10	19.67	19.51	24.72	23.97	20.53	23.23	18.13	29.63
Chowsinga/Tetracos Quadricornis	1.75	1.74	0.82	0.77	0.81	0.36	0.23	0.25	0.23	0.09	0.09	0.10	0.05	0.06	0.06	0.02	0.01	0.00	0.02
Chinkara/Gazella Gazella	0.00	0.00	0.00	0.01	0.02	0.18	0.07	0.09	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wild Boar/Sus Scrofa	0.00	0.00	0.00	10.02	8.11	7.51	9.26	11.61	11.61	11.53	11.10	11.93	12.94	15.45	15.26	9.33	14.48	15.17	16.89
Rhesus Monkey/Mecaca Mulatta	0.00	0.00	0.00	9.97	11.27	13.27	8.89	9.76	9.76	9.31	9.33	8.64	7.88	9.27	9.03	6.84	6.05	0.00	0.00
Common Langor/Presbytis Entellus	0.00	0.00	0.00	20.61	21.20	22.11	28.62	23.23	23.23	22.17	22.20	20.57	18.76	1.88	1.83	26.44	21.70	24.52	0.00
Indian Porcupine/Hystrix Indica	0.00	0.00	0.00	1.84	1.08	2.04	1.27	1.33	1.39	1.33	1.33	1.33	1.38	1.32	1.88	1.32	0.00	1.54	0.00
Wild Dog/Cuon Alpinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Civet Cat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.05	0.05	0.05	0.05	0.04	0.09	0.50	0.00
Common Palm/Civet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.07	0.07	0.08	0.08	0.06	0.04	0.05	0.00
Ratel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.21	0.20	0.23	0.22	0.16	0.13	0.16	0.00
<i>Simpson Index ($\sum P_i^2$)</i>	0.35	0.34	0.33	0.16	0.16	0.16	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.20	0.19	0.17	0.17	0.18	0.23

Notes: P_i indicates proportion of ⁱth species to total number of species available in the Sariska Tiger Reserve in a particular year.

Source: Management Plan 1978–1979 to 2004–2014 and Relocation document 2008, Sariska Tiger Reserve, Govt. of Rajasthan

Table 6 Number of families and cattle population in STR during 1982–1983 to 2008–2009

Zone	Village	Area		Family (number)		Annual compound growth (%) rate		Cattle (number)			Annual compound growth (%) rate 1982–1983 to 2008–2009	
		(Sq. km.)		1982–1983	2000	1982–1983 to 2008–2009	2008–2009	1982–1983	2000	2005		2008–2009
Core-1	Umri	74.7	10.00	52.00	59.00	82.00	8.43	250.00	1,302.00	NA	1,719.00	7.70
	Kraska	25.31	55.00	152.00	152.00	213.00	5.35	1,800.00	NA	1,978.00	2,853.00	1.79
	Rotkayala	NA	11.00	18.00	34.00	45.00	5.57	300.00	185.00	268.00	NA	-0.49*
	Sukola	NA	NA	35.00	35.00	51.00	4.82**	NA	2,853.00	574.00	NA	NA
	Kankwadi	32.17	18.00	110.00	170.00	190.00	9.49	350.00	NA	2,248.00	3,421.00	9.16
	Harpura	3.9	15.00	65.00	65.00	65.00	5.80	400.00	NA	718.00	790.00	2.65
	Lihunda	NA	9.00	13.00	13.00	19.00	2.92	200.00	790.00	398.00	NA	3.04*
	Dabli	NA	21.00	75.00	75.00	109.00	6.54	900.00	402.00	399.00	NA	-3.47*
	Raikamala	5.3	7.00	30.00	40.00	105.00	10.98	150.00	NA	525.00	NA	5.60
	Average	28.28	18.25	61.11	71.44	97.67	7.15	543.75	1,106.40	888.50	2,195.75	2.74
Core-2	Raika	NA	0.00	0.00	25.00	0.00	NA	0.00	0.00	503.00	0.00	NA
	Panidhal	NA	0.00	0.00	8.00	0.00	NA	0.00	0.00	211.00	0.00	NA
	Bera-Kali khol	NA	0.00	0.00	17.00	0.00	NA	0.00	0.00	419.00	0.00	NA
	Kala chara	2.2	12.00	0.00	61.00	0.00	7.33*	400.00	507.00	656.00	0.00	2.17**
	Barwas	13.54	39.00	0.00	103.00	0.00	4.31*	2,500.00	3,215.00	2,541.00	0.00	0.07**
	Average	7.87	25.5	0	42.8	0	6.43	1450	1861	866	0	1.76
Core-3	Kanyawas	8.37	13.00	0.00	23.00	0.00	2.51	500.00	143.00	609.00	0.00	0.86
	Mandalwas	24.37	65.00	0.00	155.00	0.00	3.85	1,500.00	1,142.00	1,647.00	0.00	0.41
	Average	16.37	39	0	89	0	3.65	1,000	642.5	1128	0	0.53
Average per sq. km.		21.10	1.45	2.90	5.45	4.63	4.57	48.72	55.51	72.13	62.12	0.94

Notes: *Indicates that the value is for the period 1982-03 to 2005 and **indicates that the value is for the period 2000 to 2008–2009.

Source: Computed from the field survey conducted in December–March, 2010–2011

In addition, growing cattle population and extensive grazing deep inside the core often led to conflicts with wildlife, injuring the cattle and helping poachers to identify the game zone of tigers and other wildlife. Further, other species like sām̄bhar, panther, chowsinga have become the second best target for the poachers in recent times. That's why core-1 was proposed to be created as the National Park, and villagers were to be relocated from the park on priority basis, along with the induction of tigers from outside in order to protect it from further degradation. Degradation and loss of species in SNP with excessive resource extraction can also be attributed to the heavy population growth and prevalent open access.

Changing fauna diversity can also be checked through the variation in proportion of each species and Simpson Index of biodiversity (SI) over time (Simpson, 1949). Wide variation in animal species in the said forest over time has been noted (Table 5). The degradation of species is true for a number of prime species, whose proportion to total species has declined. For example, tiger, panther, caracal, are very rare now a days. In addition, the proportion of Chowsinga and jackal has declined over time.

Looking at the declining value of SI one can easily say that the richness of species has improved over the years as varieties of species and total number of available species has increased during the period of analysis. The lower the value of SI indicates an increase in diversity and its distribution across the species. Therefore, it may appear to be against the hypothesis of degradation of species richness and its distribution. Rather many other species have gone up in numbers due to decline of those prime species and that is one important indicator of changing balance of species distribution. However, if one considers the evenness of the species distribution then it is found to decline over the years. The decline in some prime species has led to the increase in their prey animals like deer, monkey etc. With the reintroduction of tiger after 2005 and several measures for their protection, its proportion started increasing and led to a slight rise in SI.

6 Reasons for degradation of forest and bio-diversity in STR

Ecological sustainability of biomass extraction has been a much debated issue for long because many believe that, extraction activities compromises the aim of biodiversity conservation (Van Schaik et al., 1997). A number of studies on the impact of biomass extraction have found that, even a low level of extraction if carried out for longer period may cause significant changes in forest structure and plant composition (Murali et al., 1996; Singh, 1999; Kumar and Shahabuddin, 2005).

6.1 Growth of human population, cattle population and rising pressure on the forest resources in STR

Here, growth of population is considered to ascertain the rising pressure on the forest, (the primary source of their livelihood) that may provide an important clue for the variation in degradation across the villages in STR. It may be mentioned that until now no census has been conducted in this area. Only an estimate on the population in each cluster is available from the records of forest officials and that too in the form of number of families. Scarcely, the number of people was available only for some villages and that too not for the census years. Here a change in number of families across the villages, which is commonly available at least for some distinct years since 1982–1983 to

2010–2011, was computed. As the area of forest in which those people live is fixed, percentage growth in the number of families will be the same as the percentage growth of population considering the average family size to be constant⁶. Thus, the same would be the rate of growth of pressure on the forest for their survival. In some cases, with less population growth, pressure on forest may be more if per capita extraction rises too fast. However, the villagers in STR are still at their traditional stage and use it only for their survival needs and not for any commercial purpose, which is supported by their level of income and its change (Shahabuddin et al., 2007). These people only rear cattle for milk, and harvest minor forest produces like grazing their cattle or collect fodder, along with fuel-wood, herbs etc. The commercial pressure is there on the fauna through illegal poaching. Along with the population, thus size of cattle and its growth have been examined to find out the extent of stress and its spatio-temporal variation in the area.

Average number of families across the villages increased from 1.45 per sq km during 1982–1983 to 5.45 in 2005 and then declined slightly to 4.63 per sq km during 2008–2009. Thus it increased at an annual compound rate of 5.93% during 1982 to 2005.⁷ Simply, it grew at an annual average rate of about 12.24%. In core-1, the annual compound rate of growth of number of families was 7.15%, while that of core-2 and core-3 were 6.43% and 3.65% respectively⁸. Overall, average number of cattle increased from 48.72 per sq km in 1982–83 across the villages, to 72.13 per sq km in 2005 and then slightly declined to 62.12 per sq km during 2008–2009 (Table 6). In core-1 cattle per sq km has increased by an annual 2.74% compound rate, while it increased in core-2 and core-3 by annual compound rate of 1.76% and 0.53% respectively. The overall annual compound rate of growth of cattle population in the area has been 1.72% during 1982 to 2005. Thus, average number of families per Sq Km has become four-fold and size of cattle almost doubled in the park during past three decades despite slower growth after 2005 due to some relocation attempts and prohibition of grazing in core-1. Growth of both human and cattle in core-1 has been significantly higher than that of other core areas and thus the pressure.

Table 6 revealed severe increase of livelihood pressure in STR during last three decades. It has been compounded further due to delay in shifting those villagers to alternative occupations in a significant way. Authors' field level experience revealed continued forest-based activities as mentioned earlier, that may also be clarified by the highly significant proportional contribution of forest resources to their earning in various ways. This rising pressure has in fact intensified the human-animal conflict and multiplied degradation of flora and fauna over the years. Core-1, due to faster rise in pressure as compared to other cores, experienced faster degradation in the recent past (Table 6). It is also revealed from the faster rise in requirement of labour for collecting survival material.

Percentage of annual family income generated from different sources in various core areas demonstrates high dependency on forest. Overall 93% of total family income is generated directly and indirectly from forest and milk production (Table 7). Production of milk and selling of livestock together contributes about 15.05% (excluding the value of income from forest) of the total earning. Core-1 is found to generate about 100% of the annual earnings from forest-based sources directly or indirectly, which is marginally higher than that of core-2 (about 93.41%). Though people of core-3 overlap the outskirts buffer, they are able to generate about 88.6% of income from the forest resource extraction. Also share of earning from milk production and selling of livestock (24.65%) is very close to that of the core-2 (25.79%) as they manage partly from the fodder

collected from the market and the veterinary services available in their neighbourhood (not shown here), which raises cattle productivity. Despite high dependency of core-1 than that of the core-3 as well as core-2, they cannot avail such facilities due to its remoteness.

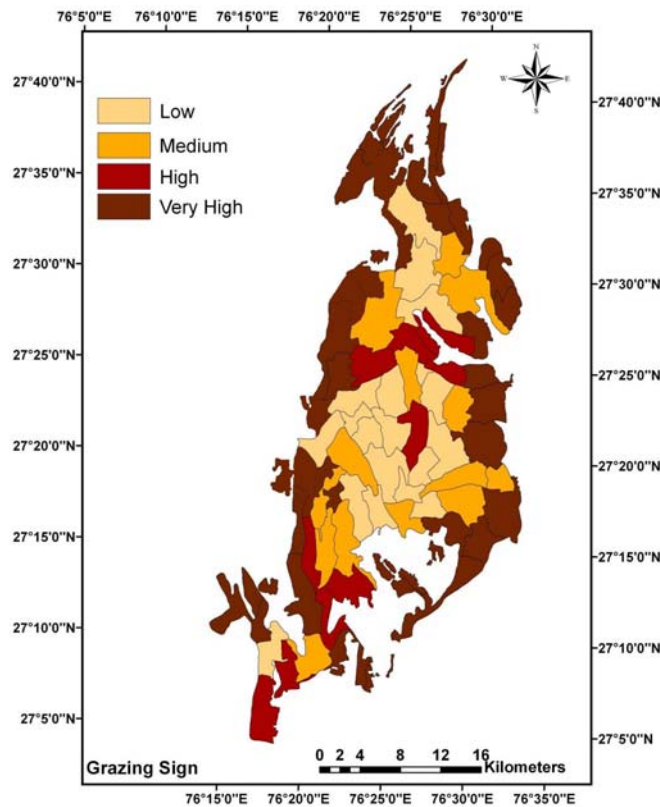
Table 7 Average share of income of the village households from different sources in STR (%)

Zone	Forest	Milk	Livestock	Agriculture	Off-Farm	Total
Core-1	84.95	8.07	6.98	0.00	0.00	100.00
Core-2	67.62	17.80	7.99	3.01	3.58	100.00
Core-3	63.95	17.79	6.86	9.15	2.25	100.00
Over all	77.80	11.80	7.21	1.98	1.20	100.00

Notes: Contribution of milk is calculated after deducting the market value of the fodder collection from the forest.

Source: Computed by the author from Field Survey data conducted during 2010–2011

Figure 4 Intensity of grazing in STR (see online version for colours)



Source: Ecological studies in Sariska Tiger Reserve, Final Report 2008, Wildlife Institute of India

Though the relative rise in population and pressure of cattle grazing has been computed and explained for various core zones and compared with the variation in degradation across those core zones, the situation of outskirts or buffer of the reserve has not been

described owing to the paucity of data. Figure-4 taken from the satellite picture (Sankar et al., 2009) on the status of Livestock grazing in STR also provides an idea about the depletion on the periphery, where wide range of brown patches represents heavy pressure of grazing and resource extraction. Similarly, high and medium grazing zone as shown here by the red and yellow patches conforms to the previously mentioned statement on the growing pressure of cattle population across the core areas (Table 6, Figure 4). Over 200 villages are located in the periphery and due to easy accessibility the buffer zone was also degraded severely over the years, leading to encroachment into the park for grazing and collection of fuel wood and fodder (Singh, 2000; WII, 2009). Forest officials on regular basis have been monitoring the encroachment status. However, due to the porous nature of park, insufficient check gates and lack of vigilance, not much protection could be extended to conserve the park. Thousands of cattle graze unaccounted, inside the park leading to severe resource conflict between the wildlife and cattle (WII, 2009).

6.2 Rising pressure on the habitat due to growth of tourism in STR

Tourism activity in the form of wildlife visitors and pilgrimage have been the regular feature of Sariska National Park (core-1) for its rich flora and fauna and unique sacred heritage of Pandupole Hanuman temple (Lord Hanuman is a Hindu God whose reference is also available in the great Epic of Mahabharata)⁹. Lakhs of pilgrims and the wild animal loving tourists from all over the country visit the park every year (Table 8) (Government of Rajasthan, 2000). A special mass arrangement for their stay and prayers inside the core-1 is made for a fortnight of each year during Pandupole Mela and Hanuman Jayanti (Hindu religious festival devoted to the lord Hanuman during the month of July-August). In addition, there are regular visitors to the temple. During this time, visitors are allowed to stay inside the parks, who otherwise are not allowed beyond the sunset, and for lighting, heating, cooking etc.; forest resources are harvested. The visitors to the park are identified based on pilgrimage and general tourists, and a significant difference is observed in terms of the behavioural attitude between the local pilgrims and those from other places, other than the Alwar district of Rajasthan. A discussion with the forest officials revealed that visitors from other places are more careful than the visitors from neighbouring areas in respect of using forest resources. Changes in inflow of tourists from 1991 also make it more clear about the changing pressure on this forest due to tourism having its effect on flora and movement of the wild animals. Also, the time series data reveal the counter-effect of degradation on tourism activities.

Though inflow of tourists in Rajasthan as a whole has been increasing over the years, tourist inflow in Sariska has been decreasing (Table-8) and profit generated from tourism businesses has been declining due to falling tourists' inflow and longer lean period. Tourist arrival in Sariska as percentage of visitors to the state of Rajasthan has declined significantly at about 15% annual exponential rate since 1991. However, total visitors to STR increased up to 2000 and thus pressure increased; it declined thereafter, which may be attributed to the deteriorating condition of both flora and fauna (Table 8). In absolute sense, annual exponential growth rate of tourist arrival during 1991 to 2008 was -3.74%, where as the figure for the state, as a whole was 10.77%. Opinion given by the 94% of the repeated visitors in the park during last five to ten years confirms severe degradation of the forest and deterioration of the park and only 6% of them responded to minor degradation. None of them asserted the improvement of the park (Table 9).

Table 8 Tourist arrival in Rajasthan and Share of Sariska during 1991 to 2008

Year	Rajasthan			Sariska			% of Sariska to total visitors of Rajasthan		
	Indian	Foreign	Total	Indian	Foreign	Total	Indian	Foreign	Total
1991	4,300,857	494,150	4,795,007	45,218	5,291	50,509	1.051	1.071	1.053
1992	5,263,121	547,802	5,810,923	51,911	6,345	58,256	0.986	1.158	1.003
1993	5,454,321	540,738	5,995,059	50,183	6,127	56,310	0.920	1.133	0.939
1994	4,699,886	436,801	5,136,687	53,527	4,883	58,410	1.139	1.118	1.137
1995	5,248,862	534,749	5,783,611	51,643	6,799	58,442	0.984	1.271	1.010
1996	5,726,441	560,946	6,287,387	65,470	7,502	72,972	1.143	1.337	1.161
1997	6,290,115	605,060	6,895,175	54,824	9,138	63,962	0.872	1.510	0.928
1998	6,403,310	591,369	6,994,679	44,633	11,558	56,191	0.697	1.954	0.803
1999	6,675,528	562,685	7,238,213	46,793	8,194	54,987	0.701	1.456	0.760
2000	7,374,391	623,100	7,997,491	45,719	19,181	64,900	0.620	3.078	0.812
2001	7,757,217	608,283	8,365,500	43,421	15,289	58,710	0.560	2.513	0.702
2002	8,300,190	428,437	8,728,627	40,260	6,824	47,084	0.485	1.593	0.539
2003	12,554,135	628,560	13,182,695	35,736	6,897	42,633	0.285	1.097	0.323
2004	16,033,896	971,772	17,005,668	44,777	12,546	57,323	0.279	1.291	0.337
2005	18,787,298	1,131,164	19,918,462	18,608	5,999	24,607	0.099	0.530	0.124
2006	23,483,287	1,220,164	24,703,451	24,186	6,428	30,614	0.103	0.527	0.124
2007	25,920,529	1,401,042	27,321,571	26,372	5,378	31,750	0.102	0.384	0.116
2008	28,358,918	1,477,646	29,836,564	34,073	4,524	38,597	0.120	0.306	0.129
Coef. of time	0.1113*	0.0602*	0.1077*	-0.0446*	0.003	-0.0374*	-0.156*	-0.0573*	-0.1451*
	(11.33)	(5.611)	(10.95)	(-4.492)	(0.16)	(-3.708)	(-9.16)	(-2.324)	(-8.168)
Adj. R ² , F	.88, 128.3	.64, 31.49	.87, 119.80	.53, 20.17	.06, .02	.43, 13.75	.83, 83.89	.21, 5.40	.79, 66.81

Notes: (1) The last row reflects the coefficient of time obtained from the log linear trend equation.

(2) Figures in the parentheses represent t-statistic.

(3) *indicates that the coefficient is significant at 1% level.

Source: Tourism Directorate of Rajasthan

However, data on local pilgrims including those from neighbouring states like Delhi, Haryana, and Gujarat during the pilgrimage, who come in thousands, go unrecorded as park remains open and entry is free on every Tuesday and Saturday. It also causes serious damage to both flora and fauna in the reserve.¹⁰ The destruction of forest habitat in turn reduces the pressure of animal loving tourists that would lead to improvement. However, no such symptom was there as several areas had already reached a critical minimum level (absolutely degraded as observed from the pictures). Unless the economic condition of the inhabited people is improved through alternative opportunities, condition of the park cannot be improved. Promotion of responsible ecotourism by involving the inhabited villagers would be an alternative option.

Table 9 Opinion of the repeated visitors about the degradation of STR till 2010–2011

<i>Time of previous visit</i>	<i>Severely</i>	<i>Minor</i>	<i>No change</i>	<i>Improved</i>	<i>Total</i>
10–15 yrs	0 (0)	2 (6)	0 (0)	0 (0)	2 (6)
5–10 yrs	31 (94)	0 (0)	0 (0)	0 (0)	31 (94)
0–5 yrs	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	31 (94)	2 (6)	0 (0)	0 (0)	33 (100)

Note: Figure in Parentheses represents percentage to total.

Source: Field Survey 2010–2011

A survey of three reputed hotels inside the park, Tiger Heaven, Tiger Den and Alwar Bagh Resort revealed a decline in number of visitors by 4% to 35%, working staffs by 20% to 35% during the last decade. In addition, insignificant increase in nominal salary of staffs and room rents as compared to hotels of neighbouring sites revealed the loss of interest of the tourists and the related economic activities simultaneously.

6.3 *Deficiency of management in STR*

Deficiency of management also has serious implications for the degradation of STR. Villagers inside the park have been the main beneficiaries of the reserve and they possess better knowledge about the topography, movement of animals, vulnerability etc. However, they have never been involved in the process of management. It is purely a system of administrative management by the forest officials who play their part as per their demarcated roles in their hierarchy without any coordination with the forest users, the villagers. Apart from the deficiency of this method, shortage of staff has remained another important issue, where scanty staff, longer working hours, outdated firearms and accessories, meagre benefits and reward caused disincentive on the part of the management of the park. There were 340 staffs in total, engaged in the management during 2000 and declined to 317 in 2004 registering a decline of 7% during the period of 4 years¹¹ (Table 10). Despite escalating degradation and crime of poaching over time, neither the labour and nor the method of management has changed much over the years. Only, steps have been taken towards the relocation of families from core-1 to faraway places with compensation and reintroduction of some tigers into the park. A large number of villagers are yet to be shifted and pressure of penetration of large surrounding communities in the buffer zone has been a continuous threat that is beyond the control of such scarce staffs without the cooperation of knowledgeable villagers. Wholehearted participation of the villagers in the process would make this possible and the cooperation

invokes relief of their economic hardship and livelihood security through the alternative provisions like ecotourism, tourist-based handicraft activities with minor forest produces vide appropriate training etc.

Table 10 Forest range staff of STR during 2000–2004–2005

S.N.	Staff	1978–1979 to 1982–1983			Percentage growth		
		2000	2004	1978–2000	2000–2004	1978–2004	
1	Conservator of forest and field director/ wildlife warden	1	1	1	0	0	0
2	Deputy conservator of forests	1	1	1	0	0	0
3	Asst. field director	0	1	1	0	0	0
4	Research officer	0	1	1	0	0	0
5	Ranger-1	0	6	6	0	0	0
6	Ranger Grade-II	1	2	2	100	0	100
7	Foresters	4	10	10	150	0	150
8	Asst. Foresters	2	15	15	650	0	650
9	Forest guards, wildlife game watchers	48	74	64	54	-14	33
10	Trekkers	0	10	10	0	0	0
11	Office support staff	7	15	26	114	73	271
12	Work charge	NA	204	180	0	-12	0
13	Over all	64	340	317	431	-7	395

Notes: Office support Staff= Accountant, Clerks, Driver, Wireless operator, Peon Orderly, Chowkidar, Sweeper, Surveyor etc.; Work charged Staff = Gate Keeper, Pump Attendants, Electrician, Gardner, Rest House Keeper, Beldar, Wireless Attendants, Cattle Guard, Daily wage Labour.

Source: Management Plan of STR, Government of Rajasthan, 1978–1979 to 1982–1983; 2004–2014

Table 11 Offences Registered in STR during 1989–1999 to 1999–2009

No.	Activities	1989–1999	1999–2009	Growth (%)
1	Illegal felling of trees	20.9	59.6	185.17
2	Illegal grazing	29.6	83.2	181.08
3	Poaching	1.9	6.9	263.16
4	Encroachment	3.9	5.3	35.90
5	Others	3.3	62.4	1,790.91
	Total	89.6	217.4	142.63

Source: Management Plans of STR, Government of Rajasthan, Various Issues.

Though, in many places JFM or participatory management has been successful (Saberwal and Rangarajan, 2000), it has never been experimented here for controlling degradation or protection of forest and wildlife. Because of the outdated security and vigilance

system, number of forest crimes is on the rise (Singh, 2004). Besides, the strained relationship between villagers and forest officials and their regular confrontation in and around the SNP is reported, which adds to the distressed condition and expose the park to further mismanagement and leading to degradation.

Changes in forest crime rate also help in understanding degradation and deficiency of management. Desperate villagers are caught and fined for grazing in the park and there are regular confrontation between the villagers and park managers on the rights of grazing and fodder collection that led to further non-cooperation. Percentage increase in annual average offences in STR from 1990s to previous decade was 142.63 (Table 11) reflecting growing loss of flora and fauna in the reserve.

As a part of the management for preservation and keeping sustainable livelihood of the villagers in core-1, relocation option has been undertaken (Chandel, 2011). Two different modes are followed for the purpose. Under option-1, a cash compensation of Rs. 10 lakh per family (for the construction of house, acquiring land and bank deposit) without any land allocation and freedom to settle anywhere is kept. Those who already own some land can also avail cash compensation but the land under their possession is not allowed to be sold for a minimum period of five years. The beneficiary can also start a new business instead of agriculture and get this monetary compensation after producing affidavit in this regard.

Under option II, each family is provided six bigha of forest land for agricultural and fodder development purposes and an individual compensation of Rs. 2.5 lakh. Also for community development work, government has allocated Rs. 1 lakh per family that would be spent on developing common property resource. In lieu of compensation for their immovable property at the existing village, housing plot of 500 sq metre in size is provided at the relocated site. In addition to the agricultural and housing plots, villager were also allocated land for roads, pasture development and green belt for grazing besides community assets and temple premises in the new settlement zone.

Table 12 PCI of the families in core areas of STR

<i>Zone</i>	<i>Surveyed population</i>	<i>Total annual income (Rs)</i>	<i>Per capita monthly income (Rs)</i>
Core-1	1,110	54,852,493	4,118.06
Core-2	569	20,558,073	3,010.85
Core-3	268	11,206,240	3,484.53
<i>Total</i>	1,947	86,616,806	3,707.28
Relocated zone	157	4,965,600	2,635.67

Source: Computed from the Field Survey, 2010–2011

Initial proposal (2005–2006) to settle 129 families from the two villages in the first phase- Bhagani (19 families) and Kankwadi (110 families), required 271 hectares of land @two hectares per family (1.5 ha. for agriculture farming and 0.5 ha. for housing). Then two more villages (Kraska and Umri) were proposed to be relocated. Land available at the proposed site of 75 Km away Bardodh Rudh was about 222 ha and 182 ha area in Mojhpur, Laxmangarh was enough for the settlement of more than 272 families (combining all four villages). Thus, good progress of family relocation was achieved during 2006–2007 to 2012–2013 with total relocation of 329 families under both the packages. However, further relocation of the remaining families is increasingly difficult

due to the scarcity of required land and sluggish approach on the part of the government to make necessary land arrangements and insistence on cash compensation approach that has few takers. Also, some villagers relocated from Karska earlier were found to return to core-1 again.

The question thus arises whether the compensation paid to villagers is enough to carry out a modest livelihood activity in the relocated area. So far, if the short-term result is considered, they are earning much less than that they used to earn inside core-1. Table-12 reveals that per capita earning from all sources including from compensation in the relocated zone is much lower than their earning in core-1. It has been due to less earning from cattle rearing and lack of experience in agriculture. However, whatever steps are taken like the earning of fixed deposit (that will come afterwards), from the development of grazing field and agricultural facilities may yield comparable long-term result. Looking at the short-term loss of those who have already shifted, problem of adjustment in the new situation and activity pattern, many villagers are reluctant to move out on compensation.

However, if the conservation benefit is accounted and one looks from a societal point of view, there may be higher net gain in relocation despite a short-term loss of the relocated villagers. Total benefit due to the conservation of forest and its biodiversity is very difficult to measure. But, the benefit accrued to the tourists at least can be measured through their willingness to pay for preservation. Using zonal travel cost method, average willingness to pay, by an individual visitor to the park (estimated from their expenditure on travel, lodging expenses, loss of opportunity cost, park fees etc) is found to be Rs 6110/- (De and Devi, 2011). This tourism is contingent upon the richness of bio-diversity and maintenance of the park. Therefore, there is a clear trade off between the welfare of those villagers and tourism, apart from other benefits of relocation and conservation. Similarly, the hospitality sector will be benefitted as revealed from the positive relationship between the degradation and falling tourist arrival, business activities etc.

Thus, the overall net gain would be there through relocation and preservation of forest bio-diversity. But the major part of earning from entry fee goes to government revenue, from lodging goes to the hotel and restaurant owners and transport business goes to the transporters. Only a part goes to the villagers who supplies materials to those restaurants and get job there. Therefore, the viable option would be to transfer a part of the benefit earned through tourism development in favour of the villagers (even though they are in the new location) then they would overcome their loss. It may be feasible by taxing tourists a bit more as they are willing to do so, or taxing the hotels and other service sector who will gain more due to preservation. In addition, the villagers may be involved in the management and development of ecotourism in the area.

7 Conclusions

Degradation of forest and biodiversity and the inhabited subsistence village economy in STR cannot be explained in isolation. These are closely inter-linked, and the strength has been under the supervision of monitoring mechanism. Overall analysis reveals significant degradation in SNP/STR over the years, which has been due to the multiple factors.

These are relentless pressure of grazing; extraction of fodder and other forest resources by the growing inhabited human population in the park, various tourism activities, and shortfall of management. Grazing and fodder collection by those pastoral communities over the years has been exerting so much pressure that vegetation in and around the park has been severely depleted and distance travelled as well as labour-hour required for those activities has increased substantially. Responses of the surveyed household from their current and past experience also confirmed the nature and extent of degradation of the park.

Tourism though a promising source of income for the state as well as people who are involved; it has some adverse impacts on the park that in turn affect the tourist arrivals itself. In the process, severe disturbance and damage to the habitat is caused. The choice of alternative (other than SNP) is also a testimony of degradation and deforestation as many of the tourists earlier visiting the park now chooses other National Parks (other than SNP/STR) due to their richness in bio-diversity. The extraction of forest resources by the villagers in the periphery and ever widening buffer zone and consequent encroachment into core zone by the villagers clearly indicates that, buffer zone has already been damaged severely. Thus in order to graze cattle and collect fuel wood, villagers have been penetrating into the core areas and a competition from within and outside the park has been taking place.

In addition to the above, the inhabitants of buffer areas practice some agricultural activities along with minor business, tourism related activities and they are also involved in the available MGNREGA or other jobs inside buffer or adjoining areas. If the core area villagers cannot be totally shifted to a suitable faraway place with alternative occupations of their standard, they can be gradually shifted to outskirts of the core areas, where they may be allowed to practice some agriculture in the forest patches along with availing MGNREGA or wage labour in the neighbouring town. Also those villagers may be encouraged to undertake ecotourism related activities for their survival. They may also be involved in the forest protection with appropriate incentives.

Problem of poaching is another reason for the degradation of prime wild species in the park and breaking of the food chain. Instances of poaching to the extent of eliminating tiger are indications of the degradation where prime fauna is challenged and wiped out completely putting others in the hierarchy at risk (Government of India, 2005). Though Simpson Index shows an apparent improvement in diversity, it is actually an indication of disturbance of balance of various animal species in the food chain and overall ecosystem of the area. Attempt of tiger relocation in SNP clearly signifies the extent of damage caused to the park and report of the wildlife institute of India, 2005 confirms the degradation in SNP. Relocation of the villagers to the new location of Bardodh-rudh Behror, Rajasthan along with the reintroduction of some tigers are some measures undertaken to counter degradation as it justifies the effort to restrain on resource extraction and allowing park to rejuvenate and bring it back to its pristine conditions. However, unless the other important aspects like appropriate compensation through benefit transfer, involving villagers to the ecotourism activities or management are addressed adequately (as there is threat from huge number of villagers in the buffer areas, whose economic conditions are highly forest dependent) the success of these efforts remains questionable.

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Notes

- 1 This forest cover is estimated based on the satellite data of Oct.-Dec. 2008.
- 2 Here many a time reserve and national park are used interchangeably.
- 3 As the forest dwellers here are not commercial and they use it only for their survival, the degradation would force them to use more labour and time for survival. It would lead to decline in children's enrolment or increase in drop out (if they were employed for such activities). Information related to those can be used as indirect indicator for the degradation across the areas.
- 4 Most of the tourists visit the park primarily for the rich fauna or wild habitats though there are some other attractions like pilgrimage, eco-tourism.
- 5 Satellite imagery of Sariska Tiger Reserve or Park is not available for the year 1969 and thus the topo-sheets are used.
- 6 The economic background of these Gujjar's is very poor and mostly they are illiterate. Hence, trend of declining family size of developed areas is not applicable to this remote forest area. It is also vindicated from the personal field level experience of the researcher's. At present, the average family size of the sample households is calculated to be about 7.
- 7 Figure for core-2 is available up to 2005. Hence, the growth rate from 1982-83 to 2005 is used to project the value of 2008. It is then used estimate the overall average family of the area and the same method is followed in case of cattle afterwards.
- 8 For core-2, it is calculated for the period 1982-83 to 2005-06 due to the availability of data.
- 9 Pandavas during their Gupta-Baas or concealed exile (exile in unknown place), met lord Hanuman on their journey to the present day Delhi (Hastinapur) in core-1 at Pandupole, which is about 22 Km. from the reception centre of the Sariska Tiger Reserve.
- 10 On those days as it becomes difficult to regulate the visitors scattered to the area of around 22 Km inside the core-1 from the Forest Reception Centre.
- 11 Comparison from year 2000 onward is done to get a clear picture because the crisis of tiger extinction was reported in 2005 and management was blamed for lack of alertness and effectiveness in protecting the park. However, the management expressed inefficiency of their part due to the inadequacy of staff and appropriate tools for the protection in the face of organised rampant poaching.