

Original Article

Assessment of Tiger Reserve Sites in India: Identification of Social Impact Indicators through the Delphi Technique

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Abstract - The Indian Tiger Reserves are a global conservation model that protects biodiversity and improves human well-being. Human disputes often follow carnivore reintroduction. Community conservation costs include livestock losses from disputes and livelihood losses from the suspension of traditional forest rights in designated areas. Tiger reserves and populations affect many indigenous and rural communities. By exclusion, Indian governments maintain protected areas. Local communities are not involved in everyday management. These communities face historical, legal, livelihood, and management issues with this strategy. There is a need to establish a set of indices important for assessing the social impact of the tiger reserve sites, along with the environmental factors, for the proper functioning of the reserve sites. This three-round Delphi study seeks expert consensus on important social impact indicators for assessing Indian tiger reserve sites. A diverse panel of thirty experts evaluated six broad indicators and nineteen specific indicators with 100% response rates in all three rounds. At each round, indicators were scored on a scale from 1 (strongly disagree) to 5 (strongly agree). Nine variables were chosen as evaluation tools for Indian tiger reserve locations with high group agreement and high correlation ranking in rounds, with livelihood impact being the most significant at 81.55%. Social Equity and Inclusion ranked second at 80%, followed by Access to Resources at 76.6%. Cultural and Recreational Impacts were next at 61.7%, followed by Displacement and Resettlement at 56.6%, and finally, Health and Well-being at 50%.

Keywords - Social Impact Assessment, Protected Areas, Human-Wildlife Conflict, Delphi Method, Tiger.

1. Introduction

The number of tiger reserves in India has risen from nine in 1973, when Project Tiger was initiated to enhance tiger conservation, to fifty-two currently. Concurrently, the tiger population has grown from approximately 1900 in the early 1970s to 2967 as of the most recent census in 2018. (Rights & Center, 2022) As a result, India is recognized as a global authority in the conservation of tigers. The National Tiger Conservation Authority (NTCA), which is under the Ministry of Environment, Forest and Climate Change, has approved the designation of Sunabeda Wildlife Sanctuary, MM Hills Wildlife Sanctuary, Guru Ghasidas National Park, and Tamor Pingla Wildlife Sanctuary as tiger reserves, in addition to the fifty-two existing tiger reserves. Furthermore, the declaration of Ratapani Wildlife Sanctuary, Dibang Wildlife Sanctuary, and Kaimur Wildlife Sanctuary as Tiger Reserves has been granted principal approval. The Government of India is deserving of recognition for the expansion of tiger populations achieved through Project Tiger.

Currently, India is home to seventy-five percent of the global wild tiger population. (Rights & Center, 2022) Reintroduction is most commonly used in strategies for conservation nowadays for large carnivores. (Marcella &

Scott, 2009) There is insufficient attention for conservation programs associated with human dimensions (Malviya et al., 2022) because, due to anthropogenic influences, Carnivores (Hartman, 1994) were eradicated in large numbers. Furthermore, the reintroduction and revival of carnivore populations often lead to conflicts with human communities.(Stahl et al. 2001; Bangs et al. 2019).

Human-driven modifications to land use on a global scale, caused by the expansion of infrastructure and related activities, alongside conservation efforts aimed at safeguarding terrestrial wildlife, have led to landscapes marked by heightened interactions between human populations and wildlife species.(Li et al., 2024) This conflict arises in areas where there is an intersection of human and wildlife habitats or where resources are utilized by both parties. Disputes in human-wildlife encounters also reveal the disagreements among human beings, and also reflect the various beliefs and demands of different stakeholders with respect to landscape uses and management.(Stevens et al., 2025) The interaction between humans and wildlife quite often results in conflict, which has an adverse impact on both biodiversity conservation efforts and the overall well-being of human populations. The conflict level goes down sharply



when you move further away from the protected zones.(Li et al., 2024). Losses in livestock due to disputes and livelihoods, and due to the suspension of customary forest rights at different authorized release sites, are two ways in which local communities bear the conservation costs.(Green et al., n.d.)

According to Malviya et al. (2022), the communities living in or near these tiger reserves heavily depend on the reserves for their daily requirements, including livestock grazing. (Jain & Sajjad, 2016). Whereas humans and tigers use these reserves' habitats very similarly, which often leads to conflicts between the two living species.(Kolipaka et al., 2017).

Having said that, the opposing viewpoint must be considered: Since tiger reserves were established and the tiger population spiked, many local populations and indigenous peoples have seen a dramatic upheaval in their way of life. whereas tribal groups located in or near protected areas were subject to legal bans on certain traditional activities as a result of the Wild Life Protection Act of 1972 (WLP Act, 1972). (Rights & Center, 2022) Forest ecosystems and other resources that they provide are now under a serious threat, even though indigenous peoples rely heavily on them for food, energy, and economic activities. However, honey harvesting, mahua flower gathering, firewood gathering, and fishing in forested areas have all put people in danger, including criminalization, gunshot, death, and torture. In 1973, the Indian government initiated Project Tiger. As part of this program, families were offered a cash incentive of Rs 100,000 to leave tiger reserves. The sum for relocation was increased to Rs 10 lakh, or one million Indian rupees, in 2008. (Rights & Center, 2022)

Changes to the biophysical environment frequently brought forth by human activity have far-reaching societal consequences. Any change that affects people, communities, and populations, as well as how those entities interact with one another, is considered to have social repercussions. These signify changes in how people participate in different parts of life, such as their housing, places of employment, leisure pursuits, interactions with others, and the organization of their communities and institutions. (Ababa, 2019) Altogether, their needs will be met, and their combined efforts will be guided by these changes. With these changes, new ways of thinking will be developed about what it means to live well and what constitutes a good life. (Ababa, 2019). The term "Social Impact" describes the effects on human populations of any public or private actions that change how people live, work, play, relate to one another, organize to meet their needs, and generally cope as members of society.(Jones et al., 2017) These social repercussions can cover a wide range of topics, including changes to "People's Way of Life," "Culture," "Community" (and its cohesiveness), "Political Systems," "Environment," "Health and Well-Being," "Personal and

Property Rights," "Fears and Aspirations," and more. Even while the number of studies on social impact evaluation has increased, there is presently no formal procedure or commonly used standard tool to evaluate the social impacts of PAs in particular. It is believed that there are two primary causes for this. First, establishing social impact indicators is a very difficult task that is continuously being developed in the field of impact assessment as well as in the literature on environmental services(Jones et al., 2017). A second problem is that social impacts can be quantified both objectively (e.g., local employment growth) and subjectively (e.g., local populations' opinions of the shift in their well-being). Social consequences are frequently only examined, if at all, from the viewpoint of the management actor in large-scale data gathering studies, offering a more objective measurement.(Jones et al., 2017) Indicators relating to well-being and social impact in the context of indigenous and local people have been analyzed specifically to be used as effective tools in protected areas. (Corrigan et al., 2018) The evidence of perceptions used for conservation improvement is complicated and expensive as an alternative. (Suich & Dawson, 2023)

The environmental and social assessment procedures established by the World Bank place significant emphasis on evaluating the effects, mostly on indigenous peoples and other vulnerable ethnic and cultural groups. These assessments consider the potential disruption or loss of their lifestyles, values, and tenure systems. (Ababa, 2019) . It is essential to take into account and include rights holders, as their social status or identity grants these individuals distinct or collective rights that demand respect from others, higher than those of other stakeholders. The rights include the fulfillment of human needs, no discrimination, having access to resources, participation in cultural or social customs, and inclusion in processes of decision-making. (Dawson & Suich, 2025) The problem lies in that the development of the protected areas is considered only based on the ecological component neglecting the social component which plays the major role in the development of the region as social, ecological components equally contribute to the enhancement of the economical aspect and all over development and working of the protected sites as the native people are the major stakeholders of the region. In the existing literature, there are no specific social impact indicators derived specifically for the assessment of the tiger reserves or the protected areas and their vicinity, considering the coexistence of the local people with the protected areas, which serves as the research gap, and further developing the social impact indicators for tiger reserves makes the study distinctive. Coexisting has to be recognized not simply as the lack of conflict, but instead as a continuous acceptability of risks and the effective management of their impacts to ensure that they remain within acceptable limits. The degree of acceptability is determined not solely by the literal load of impacts experienced by individuals (Pooley et al., 2021) but also by the prevailing social norms and beliefs

that determine both the positive and negative aspects of human-wildlife interactions.(Stevens et al., 2025)

For a comprehensive knowledge of the underlying causes of human-wildlife conflicts, it is quite crucial to investigate the correlation between protected area characteristics and these conflicts. However, better conservation strategies could be developed with this knowledge.(Li et al., 2024)

A reliable collective opinion can be elicited from a panel of experts using the Delphi method, which is a systematic approach in social research. By providing a framework for group communication, this approach helps people work together to solve difficult problems.(Landeta & Lertxundi, 2024) Several important characteristics define the methods used: (a) for example, consulting the same experts about the same issues repeatedly; (b) hiding participants identity so that experts do not know who contributed what; (c) using controlled feedback to avoid experts interacting directly; before asking for more opinions on the original questions, study leaders give everyone a summary of the group’s opinions (as a mean or median) and any relevant individual inputs; and (d) finally, a statistical group response that includes everyone’s opinions in the final product. (Rowe & Wright, 2001)

2. Material and Methods

2.1. Delphi Consensus Techniques

Formally gathering expert opinions through a series of iterative rounds and feedback processes, the Delphi technique is a systematic and aligned research methodology with the

objective of tackling intricate research issues and developing well-informed and structured resolutions. (Landeta, 2006) In a typical Delphi study, a panel of experts uses anonymous questionnaires to collect controlled feedback and iterative processes. (Nestle, 2022) However, in complex situations, when some parts of scientific information are known, but the relationships between variables are not, the idea is seen as a way to reach an agreement among experts through scientific discussion, which helps to resolve the problem.(Smith et al., 2013) On the other hand, research on natural resources and environmental management has used the technique to get more people involved in solving problems on a local, national, and international scale. Mostly, indicator development is considered to be a suitable application.(Musa et al., 2019). However, studies that have employed this method to establish subjective indicators of well-being within the expert group are very low in numbers. The Delphi method commonly has several limitations.(Landeta & Lertxundi, 2024) Specific design and the methodology overall employed in a Delphi process depend on the research question defined mostly by the analyst, and demonstrate significant variability across various studies, whereas specific design is mainly choice dependent. The Delphi study outlined in this document was designed systematically to evaluate a set of pre-established social impact indicators derived from existing literature in three rounds from the group of thirty architect, planners, Research scholars and academicians as shown in Figure 1 as it is the reliable technique of research in social areas for obtaining and seeking the experts group opinion as it is strong for obtaining indicators and building consensus.

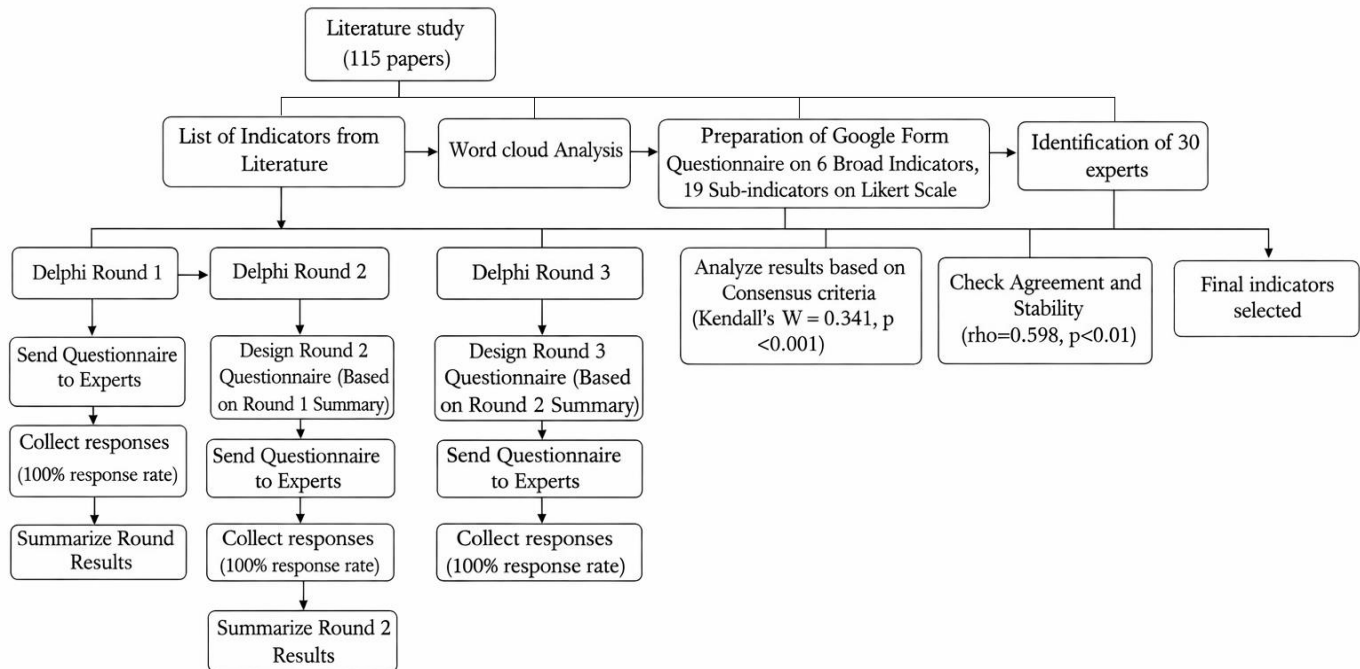


Fig. 1 Delphi methodology (source: author)

2.5. Qualitative Interpretation of 5-Point Likert Scale Measurements

Descriptive statistics (means, standard deviation, and sum) were computed for the variables in the primary analysis. The means were interpreted as follows: Strongly disagree in the point range of 1.00- 1.80, Disagree 1.81 - 2.60, Neutral 2.61 – 3.40, Agree 3.41 - 4.20, and strongly agree 4.21 - 5.00 (See table 1). (Pimentel, 2010)

Table 1. Qualitative interpretation of 5-point likert scale measurements (source: Pimentel, 2010)

Description	Likert-Scale	Interval	Rank
Strongly disagree	1	1.00- 1.80	1
Disagree	2	1.81 - 2.60	2
Neutral	3	2.61 – 3.40	3
Agree	4	3.41 - 4.20	4
Strongly agree	5	4.21- 5.00	5

2.6. Consensus Criteria

Three distinct sets of combined criteria measures are implemented to evaluate consensus. This encompasses a median score of ≥ 4 , which is deemed “highly important,” has a standard deviation of less than 1.0, and an Interquartile Range (IQR) of 1 or less, all of which are assessed on a 5-point Likert scale. The stopping criteria are established in accordance with three distinct principles to assess the degree of agreement and stability: If the third round does not meet the

following requirements, the study will cease at the end of the fourth round: Spearman’s rho between rounds must be equal to or larger than 0.9, and Kendall’s W must be equal to or greater than 0.5..(Musa et al., 2015)

2.7. Analysis of Ratings

The cumulative ratings were computed after the initial round. The thresholds set for retaining indicator items were established through a combination of criteria, which included the median, Interquartile Range (IQR), and standard deviation. Additionally, Kendall’s W was employed to evaluate the degree of agreement among participants, and the stability that was observed between rounds during the third round was also considered. Indicators that met all of these criteria were deemed to have achieved consensus. The potential impact of discrepancies in evaluations across various expert groups was assessed through a non-parametric analysis that utilized the Spearman rank correlation coefficient.

3. Results

There were 4 basic information and 19 social impact indicators chosen from the major indicators of Livelihood impacts, access to resources, Displacement and Resettlement, Health and well-being, Social Equity and Inclusion, and Cultural and Recreational impacts from the literature study, which were further taken for the Delphi method to experts in three rounds. The indicators are mentioned in Table 2.

Table 2. Indicators chosen and their descriptions (source: author)

	Indicator	Indicator description
Basic Information	B1	Age
	B2	Gender
	B3	Respondent’s role
	TR1	Have you ever visited any tiger reserve?
Livelihood Impacts	LHI1	The establishment of the tiger reserve has significantly improved the income levels of local communities.
	LHI2	Local communities have a high dependence on forest resources for their livelihood.
	LHI3	Adequate alternative livelihood opportunities have been provided to local communities.
	LHI4	The tiger reserve has generated a significant number of jobs for the local communities.
Access to Resources	ATR1	Local communities have unrestricted access to forests, grazing lands, and water resources.
	ATR2	Restrictions on resource extraction and utilization have severely impacted local communities.
	ATR3	There are sufficient alternative resources and adequate compensation measures available for local communities.
Displacement and Resettlement	DR1	A large number of families have been displaced or resettled due to the establishment of the tiger reserve.
	DR2	The rehabilitation and compensation measures for the displaced/resettled families are adequate.

	DR3	The displacement/resettlement has significantly impacted the community cohesion and social networks.
Health and well-being	HW1	The incidence of human-wildlife conflicts (attacks, livestock depredation) is high in the area.
	HW2	Local communities have good access to healthcare facilities and services.
	HW3	The nutritional status and food security of local communities have improved since the establishment of the tiger reserve.
Social Equity and Inclusion	SEI1	Do you think local communities should be involved in the decision-making process related to the tiger reserve.
	SEI2	The distribution of benefits and costs related to the tiger reserve is equitable among the local communities.
	SEI3	Marginalized groups (indigenous, women, etc.) are adequately represented in the tiger reserve management.
Cultural and Recreational Impacts	CRI1	The cultural practices and traditions of local communities have been well-preserved.
	CRI2	Local communities have unrestricted access to sacred sites and areas of cultural significance.
	CRI3	The tiger reserve has created substantial opportunities for ecotourism and recreation.

3.1. Range for Likert Scale and Rank for Round 1, Round 2, and Round 3

Table 3 shows the first round one of the indicators assessed based on the range for the Likert scale for the assessment of their rank, where indicators that are to be considered in the first round, according to the consensus, are LHI2, HW1, SEI1, ATR2, CRI3, DR3, DR1, and LHI1. Table 4 depicts the indicators that are to be considered in the second round, according to the consensus, are ATR2, LHI2, HW1, DR3, SEI1, CRI3, LHI1, CRI2, and DR1. Table 5 shows the indicators that are to be considered in the third round, according to the consensus, are CRI3, LHI1, LHI2, SEI1, DR3, ATR2, and DR1. The consensus has been achieved as they have fulfilled the criteria in which the mean should be between 3.41- 4.20 for Agree as Rank 4 and 4.21-5.00 for

strongly agree as Rank 5. Hence, the indicators based on rank assessment from all three rounds state that the Local communities are highly dependent on forest resources for their livelihood, and the human-wildlife conflicts are high in the area. The establishment of the tiger reserves has led to an increase in the income levels of local communities. They should be involved in the decision-making process related to the tiger reserve. The Restrictions on resource extraction and utilization have severely impacted local communities. However, the tiger reserve has created substantial opportunities for ecotourism and recreation. The displacement/resettlement has significantly impacted the community cohesion and social networks. A large number of families have been displaced or resettled due to the establishment of the tiger reserve.

Table 3. Round 1 range of likert scale for ranking (source: author)

Indicators	N	Sum	Mean	Std. Deviation	Rank
LHI2	30	116	3.87	1.042	4
HW1	30	111	3.70	.837	4
SEI1	30	110	3.67	1.348	4
ATR2	30	109	3.63	1.066	4
CRI3	30	109	3.63	1.351	4
DR3	30	106	3.53	1.042	4
DR1	30	103	3.43	.858	4
LHI1	30	103	3.43	1.194	4
CRI2	30	98	3.27	1.112	3
SEI2	30	98	3.27	1.202	3
CRI1	30	93	3.10	1.296	3
LHI3	30	92	3.07	.980	3
ATR1	30	90	3.00	1.174	3

HW3	30	90	3.00	.983	3
SEI3	30	87	2.90	1.242	3
DR2	30	87	2.90	.995	3
ATR3	30	87	2.90	1.125	3
B3	30	86	2.87	1.137	3
LHI4	30	76	2.53	.937	2
HW2	30	67	2.23	1.040	2
B1	30	50	1.67	.547	1
TR1	30	50	1.67	.479	1
B2	30	49	1.63	.490	1
Valid N (listwise)	30				

Table 4. Round 2 range of likert scale for ranking (source: author)

Indicators	N	Sum	Mean	Std. Deviation	Rank
ATR2	30	121	4.03	.490	4
LHI2	30	120	4.00	.788	4
HW1	30	119	3.97	.964	4
DR3	30	119	3.97	.669	4
SEI1	30	117	3.90	1.062	4
CRI3	30	116	3.87	.973	4
LHI1	30	113	3.77	.935	4
CRI2	30	112	3.73	.740	4
DR1	30	103	3.43	1.040	4
CRI1	30	96	3.20	.887	3
ATR1	30	92	3.07	1.112	3
SEI2	30	90	3.00	1.050	3
LHI3	30	89	2.97	1.066	3
SEI3	30	86	2.87	.900	3
DR2	30	86	2.87	.900	3
ATR3	30	86	2.87	1.042	3
HW3	30	81	2.70	.750	3
LHI4	30	74	2.47	.900	2
B3	30	73	2.43	.898	2
HW2	30	68	2.27	.907	2
B2	30	45	1.50	.509	1
TR1	30	41	1.37	.490	1
B1	30	38	1.27	.450	1
Valid N (listwise)	30				

Table 5. Round 3 range of likert scale for ranking (source: author)

Indicators	N	Sum	Mean	Std. Deviation	Rank
CRI3	30	122	4.07	.740	4
LHI1	30	121	4.03	.669	4
LHI2	30	119	3.97	.765	4
SEI1	30	118	3.93	.980	4
DR3	30	118	3.93	.785	4
ATR2	30	115	3.83	.747	4
DR1	30	104	3.47	.819	4
HW1	30	101	3.37	.928	3
CRI2	30	93	3.10	.960	3
LHI3	30	92	3.07	1.015	3
HW3	30	88	2.93	.868	3
SEI2	30	87	2.90	.995	3
CRI1	30	86	2.87	1.106	3
ATR3	30	83	2.77	.935	3
LHI4	30	83	2.77	.898	3
DR2	30	81	2.70	.988	3
ATR1	30	79	2.63	1.098	3
SEI3	30	77	2.57	.935	2
HW2	30	71	2.37	.809	2
B3	30	65	2.17	.950	2
B2	30	46	1.53	.507	1
TR1	30	44	1.47	.507	1
B1	30	39	1.30	.535	1
Valid N (listwise)	30				

3.2. Consensus Assessment for Round 1, Round 2, and Round 3

The survey was conducted with 30 experts, of whom six were Academicians, eighteen were Architects/ Planners/ Professionals, five Research scholars, and one from another background. The participants were of different age groups,

with twenty-two experts between 18 and 30 years, seven experts between 30 and 50 years, and one above 50 years. About fourteen experts have visited the tiger reserves, and sixteen have not visited the site but are working professionals in the field and are working in the policy sector. (See table 6)

Table 6. Demographic of the expert panel in round 1, round 2, and round 3. (source: author)

Indicators	Description	Number of persons
Role	Academicians	6
	Architect/ Planner/Professionals	18
	Other	1
	Research Scholars	5
B1	18-30	22
	30-50	7
	50 above	1
B2	Female	14
	Male	16
B3	Academicians	6
	Architect/ Planner/Professionals	18
	Other	1
	Research Scholars/ Students	5
TR1	No	16
	yes	14

Table 7 depicts the percentage analysis of the indicators in round one, which showcases that the expert strongly agrees with the highest percentage of 36.7 with the local communities should be involved for decision-making process related to the tiger reserve followed by 23.3 percent with Local

communities are highly dependent on forest resources for their livelihood and the tiger reserve has created substantial opportunities for ecotourism and recreation. (See Figures 2 and 3)

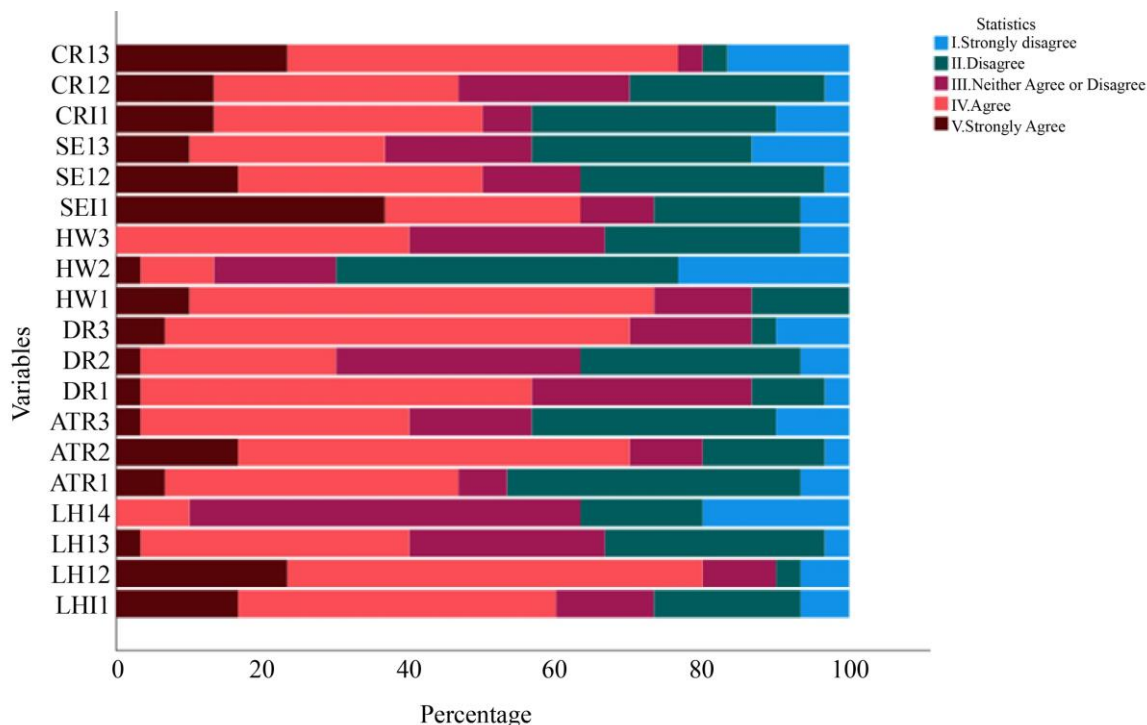


Fig. 3 Round 1 bar graph percentage analysis of all indicators on likert scale (source: author)

Table 7. Round 1 percentage analysis of all indicators on the likert scale (source: author)

Indicators	I. Strongly disagree	II. Disagree	III. Neither Agree nor Disagree	IV. Agree	V. Strongly Agree
LHI1	6.7%	20.0%	13.3%	43.3%	16.7%
LHI2	6.7%	3.3%	10.0%	56.7%	23.3%
LHI3	3.3%	30.0%	26.7%	36.7%	3.3%
LHI4	20.0%	16.7%	53.3%	10.0%	0.0%
ATR1	6.7%	40.0%	6.7%	40.0%	6.7%
ATR2	3.3%	16.7%	10.0%	53.3%	16.7%
ATR3	10.0%	33.3%	16.7%	36.7%	3.3%
DR1	3.3%	10.0%	30.0%	53.3%	3.3%
DR2	6.7%	30.0%	33.3%	26.7%	3.3%
DR3	10.0%	3.3%	16.7%	63.3%	6.7%
HW1	0.0%	13.3%	13.3%	63.3%	10.0%
HW2	23.3%	46.7%	16.7%	10.0%	3.3%
HW3	6.7%	26.7%	26.7%	40.0%	0.0%
SEI1	6.7%	20.0%	10.0%	26.7%	36.7%
SEI2	3.3%	33.3%	13.3%	33.3%	16.7%
SEI3	13.3%	30.0%	20.0%	26.7%	10.0%
CRI1	10.0%	33.3%	6.7%	36.7%	13.3%
CRI2	3.3%	26.7%	23.3%	33.3%	13.3%
CRI3	16.7%	3.3%	3.3%	53.3%	23.3%

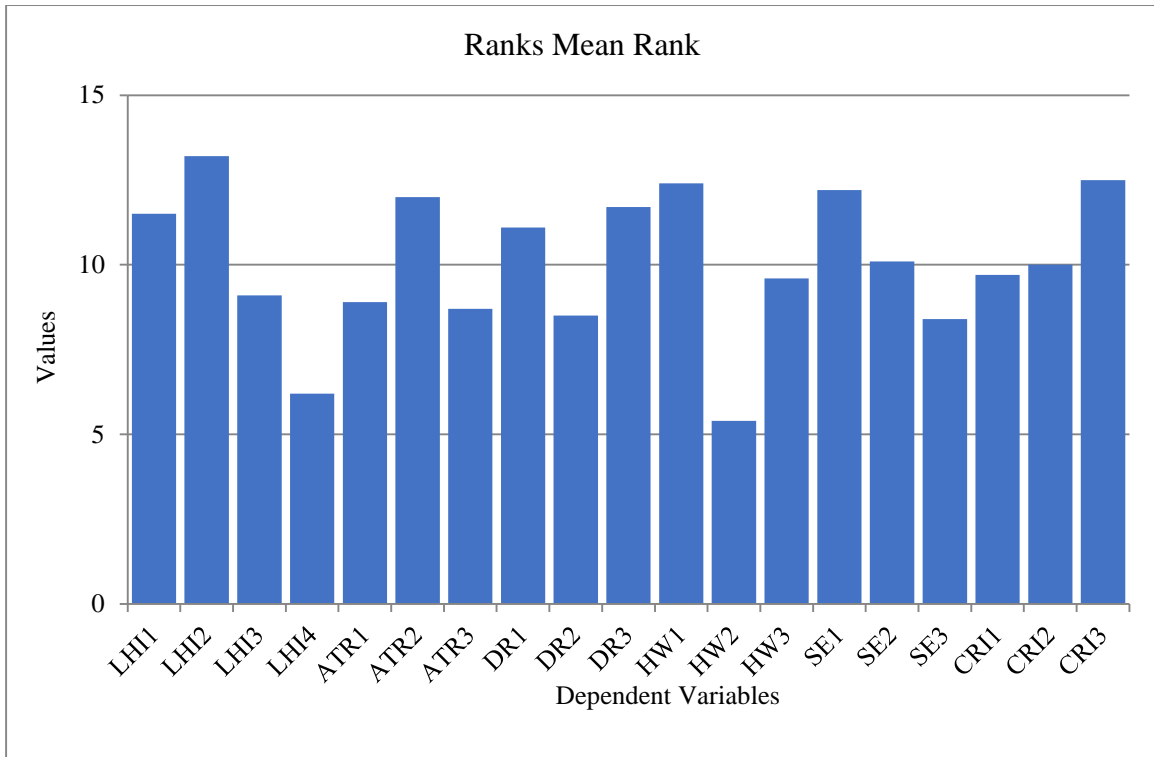


Fig. 4 Round 1 bar graph showing the indicators that reached consensus (source: author)

Table 8 depicts the percentage analysis of the indicators in round two, which showcases that the expert strongly agrees with the highest percentage of 33.3 percent that human-wildlife conflicts are high in the area, followed by 30.0 percent that local communities should be involved in the decision-

making process related to the tiger reserve. About 26.7 percent of experts strongly agree that Local communities are highly dependent on forest resources for their livelihood, and the tiger reserve has created substantial opportunities for ecotourism and recreation. (See Figures 4 and 5)

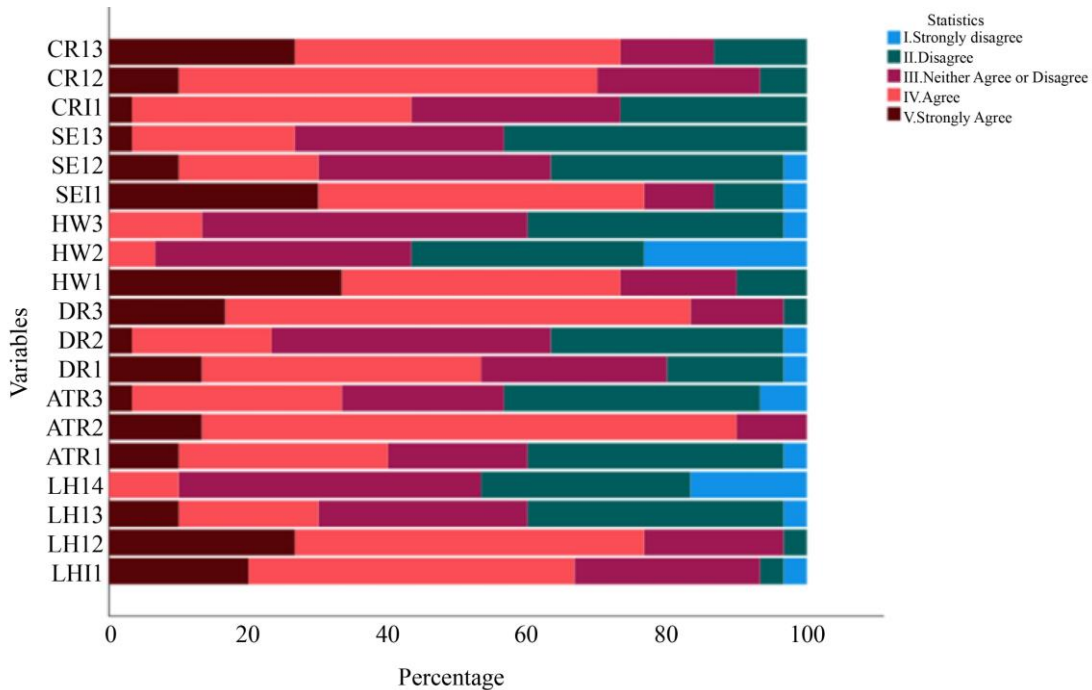


Fig. 5 Round 2 bar graph percentage analysis of all indicators on likert scale (source: author)

Table 8. Round 2 percentage analysis of all indicators on the likert scale (source: author)

Indicators	I. Strongly disagree	II. Disagree	III. Neither Agree nor Disagree	IV. Agree	V. Strongly Agree
LHI1	3.3%	3.3%	26.7%	46.7%	20.0%
LHI2	0.0%	3.3%	20.0%	50.0%	26.7%
LHI3	3.3%	36.7%	30.0%	20.0%	10.0%
LHI4	16.7%	30.0%	43.3%	10.0%	0.0%
ATR1	3.3%	36.7%	20.0%	30.0%	10.0%
ATR2	0.0%	0.0%	10.0%	76.7%	13.3%
ATR3	6.7%	36.7%	23.3%	30.0%	3.3%
DR1	3.3%	16.7%	26.7%	40.0%	13.3%
DR2	3.3%	33.3%	40.0%	20.0%	3.3%
DR3	0.0%	3.3%	13.3%	66.7%	16.7%
HW1	0.0%	10.0%	16.7%	40.0%	33.3%
HW2	23.3%	33.3%	36.7%	6.7%	0.0%
HW3	3.3%	36.7%	46.7%	13.3%	0.0%
SEI1	3.3%	10.0%	10.0%	46.7%	30.0%
SEI2	3.3%	33.3%	33.3%	20.0%	10.0%
SEI3	0.0%	43.3%	30.0%	23.3%	3.3%
CRI1	0.0%	26.7%	30.0%	40.0%	3.3%
CRI2	0.0%	6.7%	23.3%	60.0%	10.0%
CRI3	0.0%	13.3%	13.3%	46.7%	26.7%

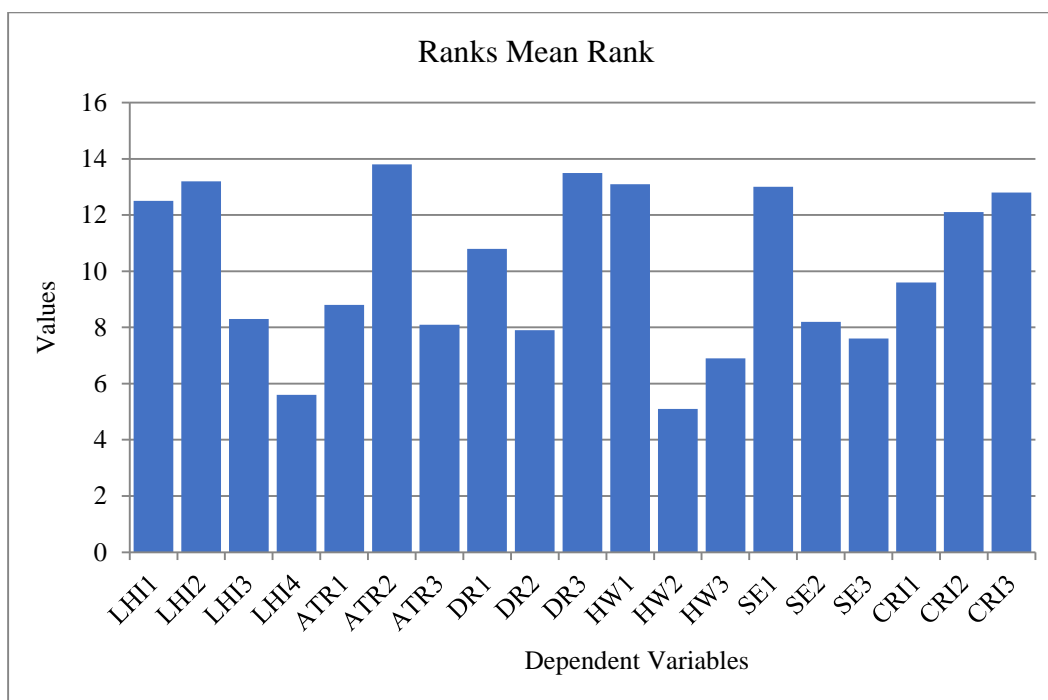


Fig. 6 Round 1 bar graph showing the indicators that reached consensus (source: author)

Table 9 depicts the percentage analysis of the indicators in round two, which showcases that the expert strongly agrees with the highest percentage of 26.7 that local communities should be involved in the decision-making process related to

the tiger reserve and the tiger reserve has created substantial opportunities for ecotourism and recreation followed by 23.3 percent with Local communities are highly dependent on forest resources for their livelihood. (See Figures 6 and 7).

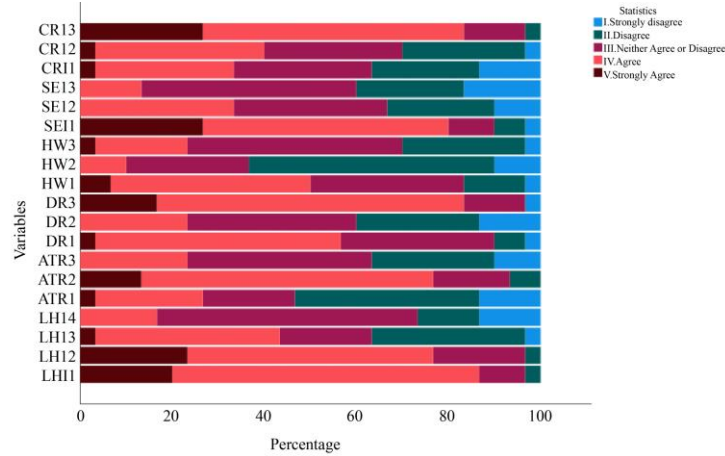


Fig. 7 Round 3 bar graph percentage analysis of all indicators on likert scale (source: author)

Table 9. Round 3 percentage analysis of all indicators on the likert scale (source: author)

Indicators	I. Strongly disagree	II. Disagree	III. Neither Agree nor Disagree	IV. Agree	V. Strongly Agree
LHI1	0.0%	3.3%	10.0%	66.7%	20.0%
LHI2	0.0%	3.3%	20.0%	53.3%	23.3%
LHI3	3.3%	33.3%	20.0%	40.0%	3.3%
LHI4	13.3%	13.3%	56.7%	16.7%	0.0%
ATR1	13.3%	40.0%	20.0%	23.3%	3.3%
ATR2	0.0%	6.7%	16.7%	63.3%	13.3%
ATR3	10.0%	26.7%	40.0%	23.3%	0.0%
DR1	3.3%	6.7%	33.3%	53.3%	3.3%
DR2	13.3%	26.7%	36.7%	23.3%	0.0%
DR3	3.3%	0.0%	13.3%	66.7%	16.7%
HW1	3.3%	13.3%	33.3%	43.3%	6.7%
HW2	10.0%	53.3%	26.7%	10.0%	0.0%
HW3	3.3%	26.7%	46.7%	20.0%	3.3%
SE1	3.3%	6.7%	10.0%	53.3%	26.7%
SE2	10.0%	23.3%	33.3%	33.3%	0.0%
SE3	16.7%	23.3%	46.7%	13.3%	0.0%
CR1	13.3%	23.3%	30.0%	30.0%	3.3%
CR2	3.3%	26.7%	30.0%	36.7%	3.3%
CR3	0.0%	3.3%	13.3%	56.7%	26.7%

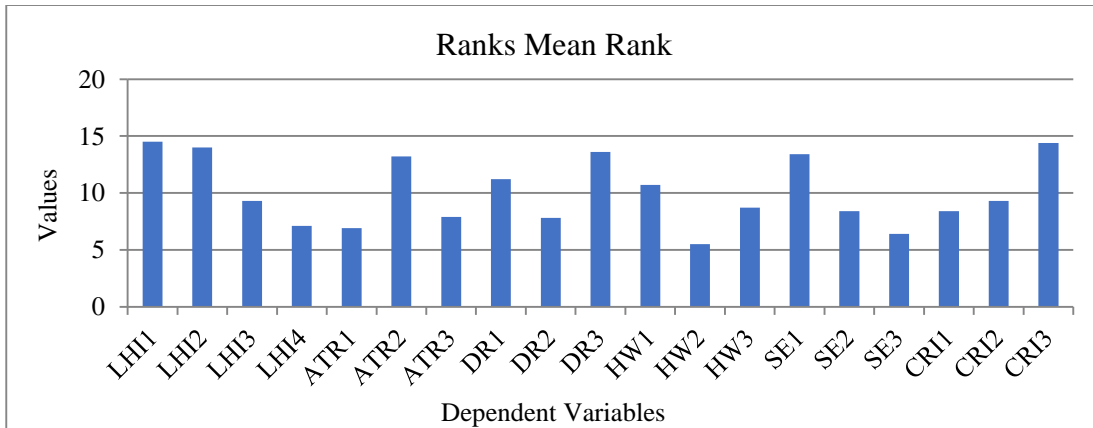


Fig. 8 Round 1 Bar graph showing the indicators that reached consensus (Source: Author)

4. Discussion

4.1. Livelihood Impacts

All the indicators from the livelihood impacts from round one show the negative value in rating results for the Identification of Social Impact dimension for the Delphi Round one consensus assessment, as it does not fulfill the criteria of consensus, as shown in Table 10. Further in rounds two and three (see Tables 11 and 12), the indicator that depicts the establishment of the tiger reserve has significantly improved the income levels of local communities, and local communities are highly dependent on forest resources for their livelihood, satisfying all the criteria of consensus assessment, and hence showcases. In contrast, the economic level has increased due to the creation of reserve sites, but locals are still highly dependent on the forests and their resources for their livelihood. So, we cannot distance local communities from the forest. There should be alternate forms of income generation for conservation of the national parks, leading to genuine generation of income (Cernea, 2006). Local communities get direct and indirect benefits generated by protected areas, such as a sense of well-being, income, and a source of food. (Steffen Foerster, David S Wilkie, Gilda A. Morelli & Malcolm Starkey, 2011)

4.2. Access to Resources

The local communities always had unrestricted access to forests, grazing lands, and water resources before the establishment of the tiger reserves. While rating the Identification of Social Impact dimension for the Delphi Round one consensus assessment, all the indicators have a negative value and do not fulfill the consensus assessment, as shown in Table 10. Further in rounds two and three (see Tables 11 and 12), the only indicator that satisfies the consensus assessment states that restrictions are laid on resource extraction and utilization from the forests after the establishment of tiger reserves, and have severely impacted local communities, leading to their identity loss. While the negative value indicators state that local communities have restricted access to forests, grazing lands, and water resources, and alternative resources and adequate compensation measures available for local communities are not sufficient. While the negative value indicator states that not adequate alternative livelihood opportunities have been provided to local communities, and the tiger reserve has not generated a significant number of jobs for the local communities, it does not contribute to their livelihood upliftment. Local people face an abundance of economic and social impacts (Cernea, 2006) as they are restricted from using the natural resources on which they relied for their livelihoods traditionally in protected areas, leading to human-wildlife conflicts and poverty. (Oldekop et al., 2015)

4.3. Displacement and Resettlement

Displacement in major cities is considered a significant social impact. The establishment of tiger reserves often leads to the displacement and resettlement of local communities

from nearby areas, including the core and buffer zones. The rating identification of social impact dimensions in the Delphi round one consensus, every indicator related to displacement and resettlement has a negative value, and does not fulfill the criteria of consensus assessment, as shown in Table 10.

In rounds two and three (see Tables 11 and 12), the indicators that satisfied all the criteria state that the displacement/resettlement has significantly impacted the community cohesion and social networks, and a large number of families have been displaced or resettled due to the establishment of the tiger reserve. So, they are deprived and facing cultural loss. While negative value indicators state that the rehabilitation and compensation measures for the displaced/resettled families are not adequate.

The displacements are forced and induced in the protected areas (Lasgorceix & Kothari, 2009) and can lead to risks like income loss and certain groups' marginalization (Cernea, 2006), and can alter the management rights and access relocation (Mascia & Claus, 2008). There are no guidelines or tools specifically for addressing the protected area displacements despite significant impacts. (Jones, McGinlay, et al., 2017)

4.4. Health and Well-Being

No indicators have been identified to fulfill the criteria of consensus assessment in rounds one and two (see Tables 10 and 11). In Round three, the indicator, which satisfies all the criteria, states that the incidence of human-wildlife conflicts (attacks, livestock depredation) is high in the area. At the same time, the negative value for the indicators in all the rounds states that local communities do not have good access to healthcare facilities and services, and the nutritional status and food security of local communities have not improved since the establishment of the tiger reserve.

Health and protected areas are indirectly linked because of the services provided in the communities. The most important social benefits for the local communities are to protect the environment as its main aim, as it increases the quality of life (Jones, McGinlay, et al., 2017), and a lot of studies indicate accessibility of state health care service in development as a significant factor. (Abreu & Mesias, 2020)

4.5. Social Equity and Inclusion

All the indicators in Delphi round one and two assessments do not qualify for the consensus criteria. (see Tables 10 and 11). In round three of the consensus assessment, the indicator that qualifies the criteria states that local communities should be involved in the decision-making process related to the tiger reserve, as shown in Table 12. However, the indicators' negative values across all rounds indicate that marginalized groups (such as women and indigenous people) are underrepresented in the management of the tiger reserve and that the benefits and expenditures

associated with the reserve are not distributed fairly among the surrounding communities.

The people must be excluded, even with force, from the protected areas for conservation in the fences and fines approach. Other opponents consider it an ethically troubling approach as exclusionist arrangements of protection, as they result in disadvantages for local people's social outcome in the protected areas, resulting in ineffective outcomes of conservation in the long term. (Oldekop et al., 2015) The protected areas must accommodate local people's needs for delivering effective and environmental long-term protection to enhance their quality and well-being, leading to securing the livelihoods, which is sustainable. (Oldekop et al., 2015)

All the indicators in Delphi round one and two assessments for this impact do not qualify on the consensus criteria. (see Tables 10 and 11). While in round three (see Table 12), the indicators which qualify the criteria state that local communities have unrestricted access to sacred sites and areas of cultural significance, and the tiger reserve has created substantial opportunities for ecotourism and recreation. The negative value indicator states that the cultural practices and traditions of local communities have not been well-preserved. The role of ecological ecosystems is very important in social, cultural, and economic functions revolving around the protected areas, and preserving the cultural and historical identity is also important for the local people's well-being and lifestyles, which are being carried out traditionally. (Leverington et al., 2008)

4.6. Cultural and Recreational Impacts

Table 10. Rating result for the identification of social impact dimension for the delphi round 1 consensus assessment (source: author)

Indicators (Round 1)			Mean	Median	Std. Deviation	Interquartile Range
Livelihood impacts	LHI1	The establishment of the tiger reserve has significantly improved the income levels of local communities.	3.43	4.00	1.194	2
	LHI2	Local communities have a high dependence on forest resources for their livelihood.	3.87	4.00	1.042	0
	LHI3	Adequate alternative livelihood opportunities have been provided to local communities.	3.07	3.00	.980	2
	LHI4	The tiger reserve has generated a significant number of jobs for the local communities.	2.53	3.00	.937	1
Access to Resources	ATR1	Local communities have unrestricted access to forests, grazing lands, and water resources.	3.00	3.00	1.174	2
	ATR2	Restrictions on resource extraction and utilization have severely impacted local communities.	3.63	4.00	1.066	1
	ATR3	There are sufficient alternative resources and adequate compensation measures available for local communities.	2.90	3.00	1.125	2
Displacement and Replacement	DR1	A large number of families have been displaced or resettled due to the establishment of the tiger reserve.	3.43	4.00	.858	1

	DR2	The rehabilitation and compensation measures for the displaced/resettled families are adequate.	2.90	3.00	.995	2
	DR3	The displacement/resettlement has significantly impacted the community cohesion and social networks	3.53	4.00	1.042	1
Health and Well-being	HW1	The incidence of human-wildlife conflicts (attacks, livestock depredation) is high in the area	3.37	3.50	.928	1
	HW2	Local communities have good access to healthcare facilities and services.	2.23	2.00	1.040	1
	HW3	The nutritional status and food security of local communities have improved since the establishment of the tiger reserve.	3.00	3.00	.983	2
Social Equity and Inclusion	SEI1	Do you think local communities should be involved in the decision-making process related to the tiger reserve.	3.67	4.00	1.348	3
	SEI2	The distribution of benefits and costs related to the tiger reserve is equitable among the local communities.	3.27	3.50	1.202	2
	SEI3	Marginalized groups (indigenous, women, etc.) are adequately represented in the tiger reserve management.	2.90	3.00	1.242	2
Cultural and Recreational Impacts	CRI1	The cultural practices and traditions of local communities have been well-preserved.	3.10	3.50	1.296	2
	CRI2	Local communities have unrestricted access to sacred sites and areas of cultural significance.	3.27	3.00	1.112	2
	CRI3	The tiger reserve has created substantial opportunities for ecotourism and recreation.	3.63	4.00	1.351	1
	Number (n)			30		
	Kendall's Coefficient of Concordance (W)			.171		
	Chi-Square			92.338		
	Level of Significance			0.05		

Table 11. Rating result for identification of social impact dimension for the delphi round 2 consensus assessment (source: author)

Indicators (Round 2)			Mean	Median	Std. Deviation	Interquartile Range
Livelihood impacts	LHI1	The establishment of the tiger reserve has significantly improved the income levels of local communities.	3.77	4.00	.935	1
	LHI2	Local communities have a high dependence on forest resources for their livelihood.	4.00	4.00	.788	1
	LHI3	Adequate alternative livelihood opportunities have been provided to local communities.	2.97	3.00	1.066	2
	LHI4	The tiger reserve has generated a significant number of jobs for the local communities.	2.47	3.00	.900	1
Access to Resources	ATR1	Local communities have unrestricted access to forests, grazing lands, and water resources.	3.07	3.00	1.112	2
	ATR2	Restrictions on resource extraction and utilization have severely impacted local communities.	4.03	4.00	.490	0
	ATR3	There are sufficient alternative resources and adequate compensation measures available for local communities.	2.87	3.00	1.042	2
Displacement and Replacement	DR1	A large number of families have been displaced or resettled due to the establishment of the tiger reserve.	3.43	4.00	1.040	1
	DR2	The rehabilitation and compensation measures for the displaced/resettled families are adequate.	2.87	3.00	.900	1
	DR3	The displacement/resettlement has significantly impacted the community cohesion and social networks	3.97	4.00	.669	0
Health and well-being	HW1	The incidence of human-wildlife conflicts (attacks, livestock depredation) is high in the area	3.97	4.00	.964	2
	HW2	Local communities have good access to healthcare facilities and services.	2.27	2.00	.907	1

	HW3	The nutritional status and food security of local communities have improved since the establishment of the tiger reserve.	2.70	3.00	.750	1
Social Equity and Inclusion	SEI1	Do you think local communities should be involved in the decision-making process related to the tiger reserve.	3.90	4.00	1.062	1
	SEI2	The distribution of benefits and costs related to the tiger reserve is equitable among the local communities.	3.00	3.00	1.050	2
	SEI3	Marginalized groups (indigenous, women, etc.) are adequately represented in the tiger reserve management.	2.87	3.00	.900	2
Cultural and Recreational Impacts	CRI1	The cultural practices and traditions of local communities have been well-preserved.	3.20	3.00	.887	2
	CRI2	Local communities have unrestricted access to sacred sites and areas of cultural significance.	3.10	3.00	.960	2
	CRI3	The tiger reserve has created substantial opportunities for ecotourism and recreation.	3.87	4.00	.973	2
Number (n)			30			
Kendall's Coefficient of Concordance (W)			.305			
Chi-Square			164.546			
Level of Significance			0.01			

Table 12. Rating result for identification of social impact dimension for the delphi round 3 consensus assessment (source: author)

Indicators (Round 3)		Mean	Median	Std. Deviation	Interquartile Range	
Livelihood impacts	LHI1	The establishment of the tiger reserve has significantly improved the income levels of local communities.	4.03	4.00	.669	0
	LHI2	Local communities have a high dependence on forest resources for their livelihood.	3.97	4.00	.765	1
	LHI3	Adequate alternative livelihood opportunities have been provided to local communities.	3.07	3.00	1.015	2

	LHI4	The tiger reserve has generated a significant number of jobs for the local communities.	2.77	3.00	.898	1
Access to Resources	ATR1	Local communities have unrestricted access to forests, grazing lands, and water resources.	2.63	2.00	1.098	2
	ATR2	Restrictions on resource extraction and utilization have severely impacted local communities.	3.83	4.00	.747	0
	ATR3	There are sufficient alternative resources and adequate compensation measures available for local communities.	2.77	3.00	.935	1
Displacement and Resettlement	DR1	A large number of families have been displaced or resettled due to the establishment of the tiger reserve.	3.47	4.00	.819	1
	DR2	The rehabilitation and compensation measures for the displaced/resettled families are adequate.	2.70	3.00	.988	1
	DR3	The displacement/resettlement has significantly impacted the community cohesion and social networks	3.93	4.00	.785	0
Health and well-being	HW1	The incidence of human-wildlife conflicts (attacks, livestock depredation) is high in the area	3.70	4.00	.837	1
	HW2	Local communities have good access to healthcare facilities and services.	2.37	2.00	.809	1
	HW3	The nutritional status and food security of local communities have improved since the establishment of the tiger reserve.	2.93	3.00	.868	1
Social Equity and Inclusion	SEI1	Do you think local communities should be involved in the decision-making process related to the tiger reserve.	3.93	4.00	.980	1
	SEI2	The distribution of benefits and costs related to the tiger reserve is equitable among the local communities.	2.90	3.00	.995	2
	SEI3	Marginalized groups (indigenous, women, etc.) are adequately represented in	2.57	3.00	.935	1

		the tiger reserve management.				
Cultural and Recreational Impact	CRI1	The cultural practices and traditions of local communities have been well-preserved.	2.87	3.00	1.106	2
	CRI2	Local communities have unrestricted access to sacred sites and areas of cultural significance.	3.73	4.00	.740	1
	CRI3	The tiger reserve has created substantial opportunities for ecotourism and recreation.	4.07	4.00	.740	1
Number (n)					30	
Kendall's Coefficient of Concordance (W)					.341	
Chi-Square					184.184	
Level of Significance					0.01	

4.7. Test of the Level of Agreement and Stability

Three particular rules make up the halting criteria, which are used to assess the degree of agreement and stability: Spearman's rho between rounds must be ≥ 0.9 , and Kendall's W must be ≥ 0.5 . If these requirements are not met by the third round, the study will cease at the end of the fourth round. (Musa et al., 2015) Kendall's W value is quantified on a scale from 0 to 1, with values greater than 0.7 indicating a strong level of consensus, a value of 0.5 reflecting moderate consensus, and values less than 0.3 signifying weak consensus. (Roy C. Schmidt, 1997) According to Cohen (1975), A high correlation is said to be indicated by a correlation coefficient (W) of 0.5 or above. (Musa et al., 2019) To assess the potential effects of rating changes among expert groups across rounds, a non-parametric analysis was performed using the Spearman ranking correlation coefficient. To make sure the panel consensus was solid, we looked at the predetermined criteria in detail.

In round one, the consensus W of 0.1 reveals a very weak agreement, not significant, and not satisfactory, which means there is a very weak agreement of responses in rounds. Thus, the degree of group agreement among expert rankings is extremely low. Additionally, a substantial positive correlation at the 0.05 level of significance ($Rho=0.964$, $p<0.001$) is revealed by calculating Spearman's rank correlation coefficient to assess the stability of expert evaluations between rounds, as Table 11 illustrates. This finding indicates a high degree of stability in the experts' opinions within the study. In round two, the consensus W is 0.3, which means there is a weak agreement of responses in rounds. There is a low level of agreement among experts' rankings. Furthermore, Spearman's rank correlation coefficient was calculated to evaluate the stability of expert ratings across rounds, as shown in Table 12. The results demonstrate a strong positive correlation at the 0.01 level of significance ($Rho=0.964$,

$p<0.001$), suggesting a substantial degree of stability in the experts' opinions within the study.

In round three, the consensus W is 0.3, which reveals a significant but not satisfactory enough agreement, which means there is a weak agreement of responses in rounds. So, there is a weak level of group agreement among experts' rankings.

Furthermore, the Spearman's rank correlation coefficient was calculated to evaluate the stability of expert ratings across rounds, revealing a strong positive correlation at the 0.01 level of significance ($Rho=0.964$, $p<0.001$). This finding indicates a high degree of stability in the experts' opinions within the study. The Kendall's W and Spearman's rho result indicates that a stopping condition is achieved in round three.

4.8. Selected Set of Indicators

The questionnaire concluded with a question asking the experts to assess the relative weight of each of the six dimensions in the social impact indicators assessment. After a detailed analysis, 9 Indicators to be considered according to the Delphi method from 19 indicators chosen from the literature study (See Table 13) provide the conclusive set of indicators chosen, together with their respective weight within each dimension.

Experts determined that the six dimensions should be assigned varying weights to reflect their contributions to social impact assessment, with livelihood impact being the most significant at 81.55%. Social Equity and Inclusion ranked second at 80%, followed by Access to Resources at 76.6%. Cultural and Recreational Impacts were next at 61.7%, followed by Displacement and Resettlement at 56.6%, and finally, Health and Well-being at 50%.

Table 13. Social impact indicators were selected from the delphi method. (source: author)

Indicator		Indicator Description
Livelihood impacts (81.55%)	LHI1 (86.7%)	The establishment of the tiger reserve has significantly improved the income levels of local communities.
	LHI2 (76.6%)	Local communities have a high dependence on forest resources for their livelihood.
Access to resources (76.6%)	ATR2 (76.6%)	Restrictions on resource extraction and utilization have severely impacted local communities.
Displacement and resettlement (56.6%)	DR1 (56.6%)	A large number of families have been displaced or resettled due to the establishment of the tiger reserve.
	DR3 (83.4%)	The displacement/resettlement has significantly impacted the community cohesion and social networks.
Health and well-being (50%)	HW1 (50%)	The incidence of human-wildlife conflicts (attacks, livestock depredation) is high in the area.
Social Equity and Inclusion (80%)	SEI1 (80%)	Do you think local communities should be involved in the decision-making process related to the tiger reserve
Cultural and Recreational impacts (61.7%)	CRI2 (40%)	Local communities have unrestricted access to sacred sites and areas of cultural significance.
	CRI3 (83.4%)	The tiger reserve has created substantial opportunities for ecotourism and recreation.

5. Conclusion

Sustainability depends on the economic, social, and environmental factors of the place. Although environmental impact assessments have been incorporated as a criterion in evaluating tiger reserve sites, the social dimension, which significantly influences the environmental factors of the region, has not been considered. Furthermore, no indicators have been established to evaluate the effective functioning of the tiger reserve sites as part of the assessment process. A collection of indices that serve as consensus-based social impact indicators for evaluating India's tiger reserves has been developed through a three-round Delphi survey, drawing on the vast experience of subject-matter specialists. The analysis reveals that 9 key indicators are derived from a selection of 19 indicators identified through a literature review according to the Delphi method. This research established a framework that incorporates a set of essential social impact indicators aimed at evaluating the social effects on communities adjacent to tiger reserves. Experts have established the significance of every attribute in constructing an index to evaluate the social impact assessment of tiger reserves in India to improve the well-being of the local communities near the tiger reserves. It has been determined that, alongside the environment, social factors significantly contribute to the development and

effective functioning of tiger reserves, thereby challenging the notion that only environmental indicators are considered in the evaluation of tiger reserve sites.

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Authors contribution

Sameen Fatma: Conceptualization, Roles/Writing – original draft; Writing, Data curation; Methodology, Formal analysis, Validation, Review and editing

Manoj Kumar: Conceptualization, Review and editing, and Supervision.

Conflict of interest

The authors declare no conflicts of interest.

Data Availability Statement

The data used to generate the results in the paper are available on request.

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