

Impacts, Perception and Attitude of the Fringe Population towards Wildlife of Nongkhyllem Wildlife Sanctuary–Reserved Forest, Meghalaya, Northeast India

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ABSTRACT

Protected areas such as national parks and wildlife sanctuaries are established by the state or some legal means to conserve and protect declining wildlife due to human overexploitation. However, the effectiveness of the protected area gets compromised even after the exclusion of humans from within it. Threats still exist from the humans settled outside the boundary, and Nongkhyllem Wildlife Sanctuary–Reserved Forest is one such contiguous forest in Meghalaya state of India where we have studied the impacts, perceptions, and attitudes of the fringe population towards wildlife. Since the establishment of the wildlife sanctuary in 1981, the fringe population has grown by 233% in three decades (1981–2011). The number of settlements has also increased from 28 to 37 at 32.14%, impeding wildlife movement. Overall, gradual population growth was recorded except in 1991–2001, with an exponential increase of 467%. The population increase was mainly in settlements near the road and urban areas. This highlights the urban area and roads as the population pull factor.

The Chi-square analysis for human perception and attitude showed a significant relationship between gender and issues with wild animals, age and people's willingness to engage in wild animal conservation, age and people's entry into the Nongkhyllem Wildlife Sanctuary–Reserved Forest, and lastly, age and the knowledge on the importance of wild animal conservation. Even though the area's wildlife significantly impacts their social, economic, and mental well-being, 98.89% of the fringe population have a positive attitude and perception towards it. To maintain the same positive perception and attitude of the fringe population towards wildlife, the management should focus on developing other population pull factors and look for measures to control the fringe population and settlements.

Keywords: *Protected area, fringe settlements, human population growth, human-wild animal interaction, human-wildlife conflict, perception and attitude*

INTRODUCTION

The concept of protected area (PA), which is accepted worldwide, came by the end of the 19th century for the conservation and protection of declining wildlife, particularly in those areas which were colonised by the new immigrants after the middle of the 15th century (Worboys *et al.*, 2015). The IUCN 2022 annual report defines a protected area as a geographical space recognised, dedicated, and managed through a legal or other effective

means to achieve the long-term conservation of nature with associated ecosystem services and cultural values (IUCN, 2023). To date, there are around 2,53,419 PAs around the world, which cover 15.79% of the terrestrial land of the earth (UNEP-WCMC and IUCN, 2020).

India has 998 PA, covering an area of 1,73,629.52 km², approximately 5.26% of the total geographic area of the country (Wildlife Institute of India, 2022). The PAs are categorised as National Parks,

Wildlife Sanctuaries, Conservation Reserves, and Community Reserves [Wildlife (Protection) Amendment Act, 2002]. In India, the rights of the people living inside the Community Reserves, Conservation Reserves, and Wildlife Sanctuary are not much affected, but in the case of National Parks, human settlements are not allowed inside the park, and all the rights of the people are ceased [Wildlife (Protection) Amendment Act, 2002]. However, the majority of the PAs are surrounded by human settlements, either resettled from inside of the PA or migrated from other regions (Wittemyer *et al.*, 2008).

These human settlements around the PA (outside the notified boundary of the PA) are called forest fringe villages, and people living in these settlements are called fringe populations. The Forest Survey of India defines forest fringe villages as those that fall 5 km from the forest area (Forest Survey of India, 2019). The exact definition and 5 km distance from the boundary of the Nongkhylllem Wildlife Sanctuary–Reserved Forest (NWLS–RF) was considered for this study.

The fringe population is in direct contact with the PA and influences the success or failure of conservation and wildlife protection (König *et al.*, 2020). Now, such PAs are the primary defense for biodiversity conservation from humans and their onslaught (Jones *et al.*, 2018). However, the effectiveness of a PA can be undermined due to anthropogenic pressures like growing population, roads, and other infrastructure developments, deforestation, and land encroachment in the fringe area (Jones *et al.*, 2018; Wittemyer *et al.*, 2008).

Majorities of the PAs, like those in Africa and Latin America, have witnessed an accelerated human population growth around the fringe area of the PAs, creating several disturbances like poaching, habitat fragmentation, etc. (Narain *et al.*, 2005; Wittemyer *et al.*, 2008). Similar threats to the PAs are also present in India (Ghosh-Harihar *et al.*, 2019).

Along with the active participation of the local community, a positive perception and attitude of the community is also essential for successful biodiversity conservation, which management authorities often overlook (Subedi *et al.*, 2020; Kolinski and Milich, 2021). Studies on human perception and attitudes towards wildlife have been carried out in a few states of Northeast India, such as Arunachal Pradesh and Assam (Jyrwa *et al.*, 2020; Das *et al.*, 2020). However, no studies have been carried out in the protected areas of Meghalaya, where the State Forest Department controls only 5% (1,145.19 km²) of the State's geographical area. The remaining 95% (14,629 km²) of the forest areas are owned by communities, clans, and private people (Menon *et al.*, 2019; Meghalaya Forest Department, 2022^a). The present study on the fringe area of NWLS–RF aims to understand the impacts of human settlements and population growth and how the fringe settlers adjust their life to the various notified Reserved Forest (RF) and PA legal rules and regulations. Further, the attitude and perception of the fringe population towards the wildlife and their conservation inside and around were also assessed

within a PA and RF of Meghalaya, where most of the forest area belongs to the people.

STUDY AREA

The study was conducted in the fringe area of the contiguous protected forest, Nongkhylllem Wildlife Sanctuary (NWLS)–Nongkhylllem Reserved Forest (NRF). The NWLS is located in the Ri Bhoi district of Meghalaya, India. It lies between 92°00'0" E

longitude and 25°00'0" N latitude. The NRF was established in different stages from 1909 to 1939 with a total area of 125.91 km² (MPNWLS 2017–18 to 2021–22). In 1981, a portion of this protected area was carved out as a wildlife sanctuary named Nongkhylllem Wildlife Sanctuary (NWLS). To see the anthropogenic impacts on the wildlife of the NWLS–RF, the fringe area within the 5 km range of the NWLS–RF was considered (Fig. 1).

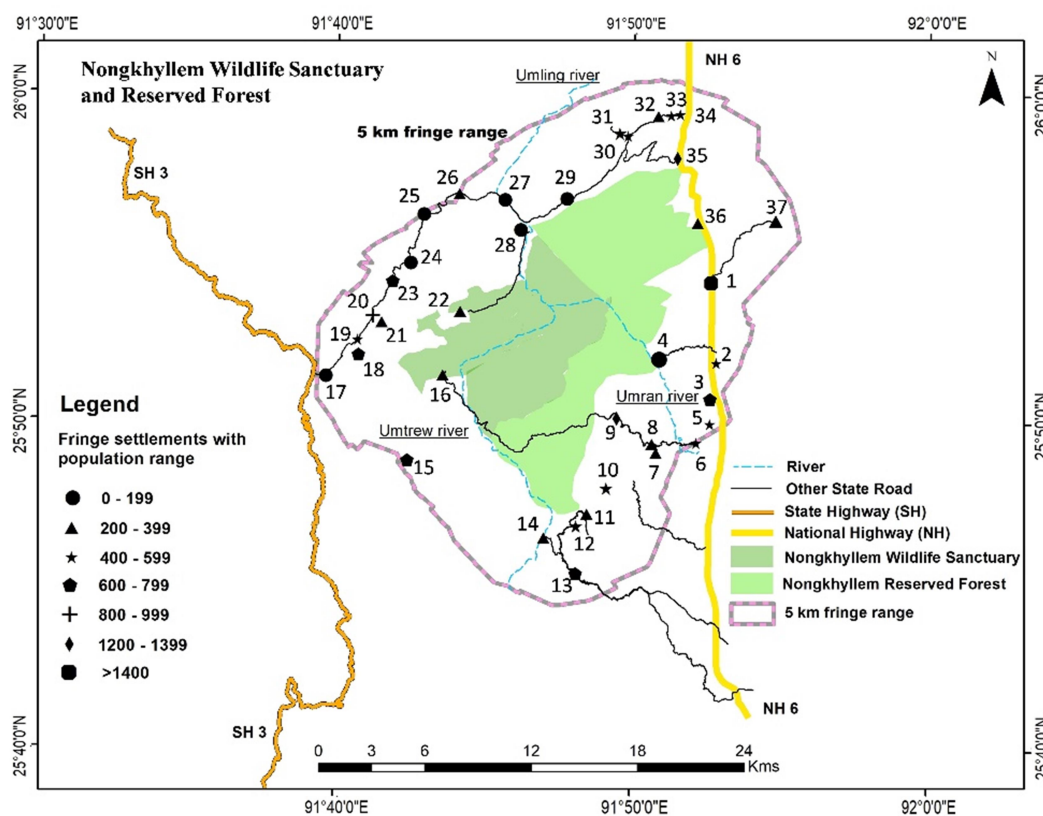


Fig. 1. Reference map of the NWLS–RF with fringe settlements under a 5 km range from the protected area. Settlements in the map are indicated as superscripted code: Nongpoh¹, Pahamrinai², Umdihar³, Iewsier⁴, Umsaw Nongkharai⁵, Quinine⁶, Umtasor Nongjyrm⁷, Maweitnar⁸, Umtasor Mawdkhar⁹, Nongrim Umksih¹⁰, Mawpyrhut¹¹, Nongmahir¹², Umdiker¹³, Nongdiengngan¹⁴, Umtngar¹⁵, Ummar¹⁶, Umtasen¹⁷, Nongwah Mawlein¹⁸, Nongbirthem¹⁹, Umsong²⁰, Nongwah Mawtamur²¹, Nongkynrih²², Nongladew²³, Jalithem²⁴, Nongwah Mawpnar²⁵, Tasku Rim²⁶, Umsohma²⁷, Lailad²⁸, Umladoh²⁹, Umdu³⁰, Sohkhwai³¹, Kongripara³², Narang³³, Paham Mawlein 20th Mile³⁴, Umling³⁵, Umling Lambrang³⁶, Nongtyrlaw³⁷

METHODS

A NWLS–RF boundary map was acquired from a secondary source and processed using software ArcGIS 10.2.2. An aerial distance of 5 km fringe range was laid from the boundary of the NWLS–RF to generate a list of settlements. The aerial distance from the fringe villages to the boundary of the NWLS–RF and the roads (National Highway 6, State Highway 3 and Other State Roads, which includes major district roads, other district roads, and village roads) was measured using Google Earth Pro.

Though the NRF was established in 1909 and the NWLS in 1981, the data regarding the fringe human population and settlements were acquired from the Census of 1981 and onwards (Census 1981; Census 1991; Census 2001; Census 2011). Around 32,753 people reside in the 37 fringe settlements of NWLS–RF (Census 2011). The location and population size (as per Census 2011) of the villages are indicated as symbols (Fig. 1). A structured interview was carried out through random sampling in the 10 (out of 37) fringe settlements to understand the attitude and perception of the fringe population towards wild animals. A single respondent was considered to represent a single household. Out of 10 settlements, nine are rural where 10% of the households were surveyed, and Nongpoh is the only urban settlement in the fringe area, where 61 households were surveyed.

A total of 181 household were surveyed in one urban, Nongpoh¹ (61 households of total 3,160 households) and nine rural settlements (villages) which include Pahamrinai² (10 households of total 88 households), Umdihar³ (21 households of total

144 households), Iewsier⁴ (5 households of total seven households), Nongkynrih²² (11 households of total 39 households), Nongwah Mawpnar²⁵ (10 households of total 19 households), Tasku Rim²⁶ (21 households of total 68 households), Umsohma²⁷ (13 households of total 26 households), Lailad²⁸ (17 households of total 39 population) and Umladoh²⁹ (12 households of total 26 households). Both male (104) and female (77) informants, who were either heads (76) or members (105) of a single household, were targeted. The respondents aged 15 and above were considered as they could read, write, and converse intellectually and were also primarily engaged in agriculture and other activities for earning their livelihood. The survey was conducted using close-ended and open-ended questionnaires (Merkebu and Yazezew, 2021), collated, and analysed in DATAtab. Permission was obtained from the Meghalaya Forest Department and the village headmen to conduct the study.

RESULTS AND DISCUSSION

The role of notified PAs has become crucial for the conservation and protection of biodiversity due to the tremendous increase in human population and their activities (Prato and Fagre, 2014). Wildlife and all types of biodiversity are essential for the sustainable living of human species on the planet earth (Menon *et al.*, 2019). However, these PAs are facing various threats, including those from human settlements and population growth, even in the fringe areas (Wittemyer *et al.*, 2008). The NWLS–RF is one such significant area protected in Meghalaya, where we studied the impacts of fringe population and infrastructure development on the wildlife of

the NWLS–RF. Fringe settlement, fringe population, and infrastructure developments are some of the parameters to measure the impact on the conservation and protection of wildlife inside and around the PA, and many studies point to these parameters as one of the major causes for the decrease or increase in the biodiversity of the PA (Wittemyer *et al.*, 2008; Nishank, 2021).

Among 181 respondents, 57.5% were males and 42.5% were females and the average age of all the respondents was 37.92 (SD = 14.26, range = 15–88). Around 58.01% were members of the house and 41.98% were heads of the house. On average, the age of member respondents were 31.18 (SD = 11.63, range = 15–66), and the head respondents were 47.24 (SD = 13.74, range = 24–88).

ATTITUDE AND PERCEPTION OF THE FRINGE POPULATION

The success of conservation and wildlife protection in a protected area greatly depends on the attitude and perception of the fringe population (Allendorf *et al.*, 2006). In Meghalaya, people have the tradition of having some forests and groves exclusively for wildlife, which are treated as sacred (Tiwari *et al.*, 1998).

Among the respondents in our study, a significant association was found between gender and the

issues of wild animals, age and the people's willingness to engage in wild animal conservation, age, and entry into NWLS–RF, and lastly, age and the knowledge on importance of wild animal conservation. Around the NWLS–RF fringe region, 98.89% of the people in the survey responded that they like wild animals, even though around 61.33% of the respondents faced issues from wild animals such as tigers, elephants, wild boars, monkeys, civets, snakes, porcupines, rats, in the form of crop depredation, livestock depredation or simply out of fear (Fig. 2, Table 1).

The Chi-square analysis showed a significant association between gender and issues with wild animals, $\chi^2(1) = 6.44$, $p = 0.011$, Cramér's $V = 0.19$. Around 39.78% of the male respondents had issues with the wild animals, which indicates that females (20.99%) were more tolerant of the wild animals. The level of tolerance towards wild animals is influenced by gendered perceptions (Carter and Allendorf, 2016). Further, the majority, 66.85% of the respondents, do not enter the forest area of NWLS–RF, but issues from wild animals prevailed through direct and indirect impacts (Table 1). The visible or immediate effects of the wild animals are usually compensated. However, the indirect or hidden impacts are not addressed, jeopardizing wildlife conservation efforts (Barua *et al.*, 2013).

Table 1. Direct and indirect impacts from the wildlife of the NWLS–RF.

Sl. No.	Direct impacts		Indirect impacts	
	Impacts	Respondents (%)	Impacts	Respondents (%)
1	Crop depredation	9.77%	Mental disturbance	2.21%
2	Attack on humans	3.88%	Change in agriculture practice	1.66%
3	Livestock depredation	5.52%	Human movement restriction	1.10%
4	Property damage	1.10%		

The factor age was also found to highly influence the willingness of individuals to engage in wild animal conservation efforts in the NWLS–RF, $\chi^2(4) = 42.5$, $p = < 0.001$, Cramér's $V = 0.48$. Most (95.03%) of the respondents were willing to engage in wild animal conservation activities despite facing issues from the wildlife, indicating a positive perception of wild animals and their conservation efforts. Around 4.97% of the respondents were not willing to conserve wild animals. These responses were recorded from all age categories of less than 19 (0.55%), 20–39 (1.66%), 40–59 (0.55%), 60–79 (1.10%), and more than 80 (1.10%). The Chi-square analysis also showed a significant relationship between age and conservation of wild animals, $\chi^2(8) = 25.95$, $p = 0.001$, Cramér's $V = 0.27$. The majority of respondents (96.13%) of all age groups agreed for wild animal conservation, 2.21% disagreed with wild animal conservation, except age group of 60–79, and the remaining 1.66% expressed "no idea", particularly of age group 40–59 (1.10%) and 20–39 (0.55%).

Cultural beliefs and knowledge influence people's perceptions and attitudes towards wild animals (Saraswat *et al.*, 2015). This positive perception and

perspective in the study area were shaped by reasons such as wild animals being creatures of God, providing aesthetic beauty, and playing an ecological role in the nature. Further, the people in the region were initially nature worshippers known as *Niam Khasi*. However, the acceptance of preserving certain wild animals like snakes, wild boars, and monkeys were low due to fear and the extensive agricultural and economic damage caused by these species.

Unlike reports in other PAs (Mishra *et al.*, 2003), the fringe population of NWLS–RF has not strongly retaliated towards wild animals. However, in some instances, people of fringe areas of the NWLS–RF have strongly retaliated due to the damage done to their primary source of sustenance and, secondly, when they do not get proper compensation for the damage. The direct attacks by wild animals on the people in the region are very few, limited primarily to snakes (2.76%), followed by wild boars (0.55%) and elephants (0.55%).

A significant association was also present between the respondent's age and their entry into the NWLS–RF, $\chi^2(20) = 100.45$, $p = 0.001$, Cramér's $V = 0.37$. People aged between 20 and 59 enter the

forest for numerous purposes (Fig. 3). The movement of the fringe population into the NWLS–RF is limited. Maximum respondents (67%) said they never enter the forest, while the remaining respondents (33%) enter the forest and may interact with the wild animals once a year (15%), once in six months (10%), every month (4%), every week (3%) and daily (1%) for collecting vegetables, medicinal plants, leaves for wrapping food items, extraction of bamboo, fallen tree branches for use as firewood and other activities such as fishing, hiking and for leisure (Fig. 2 and 3). Thus, this

indicates that the majority (67%) of respondents do not interact with the wild animals of the NWLS–RF. However, whatever interaction there is, it is in the fringe area. It was found that the majority (80%) of the respondents who entered the NWLS–RF were from Iewsier⁴, which is located at an aerial distance of 1.1 km from the NWLS–RF, followed by Umladoh²⁹ (58.33%) at an aerial distance of 100 m from the NWLS–RF and the urban settlement, Nongpoh¹ (44.26%) which is at an aerial distance of 2.3 km from the NWLS–RF, mainly for collecting wild vegetables and firewood (Fig. 3).

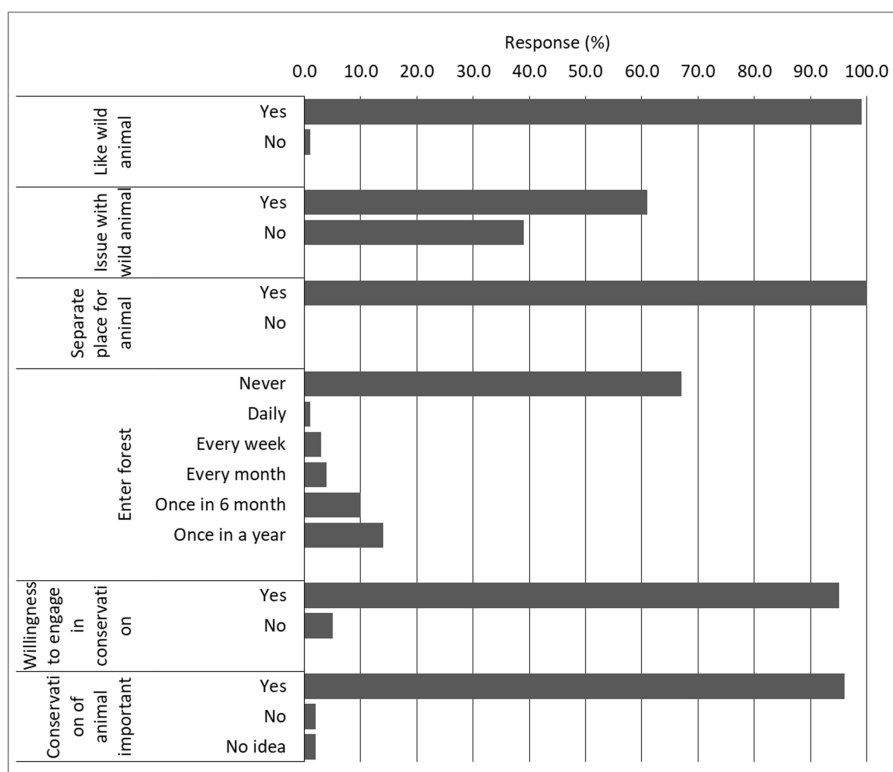


Fig. 2. Attitude and perception of the fringe population around the NWLS–RF.

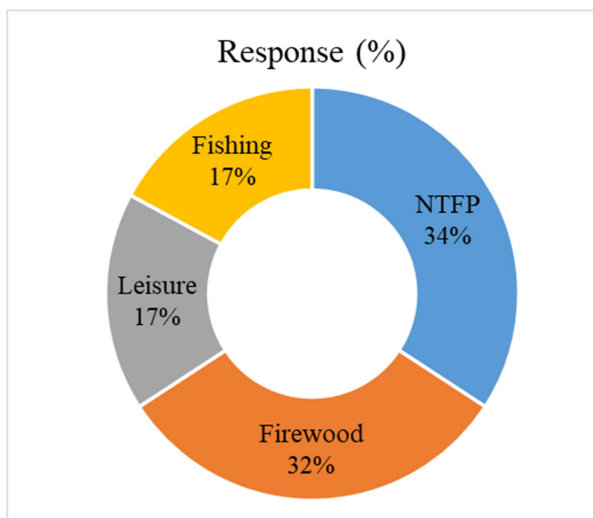


Fig. 3. People's response for entry inside the NWLS-RF.

FRINGE SETTLEMENTS AND FRINGE POPULATION

There are reports that the fringe area population and the developed infrastructures significantly affect the success of PA conservation and preservation (Wittemyer *et al.*,2008; Nishank, 2021). In 1981, when some part of NRF was declared as NWLS, the fringe area population was around 9,822 settled in 28 villages, which increased to around 9,921 by 1991, a decadal growth of just 1.01%, which is comparatively very low than the population growth (32.96%) of the entire state of Meghalaya, (Fig. 4, Table 2). During this decade, the number of new villages (settlements) increased by five only in the fringe area of NWLS-RF (Table 2).

However, in the second decade, that is, from 1991 to 2001, the fringe population around the NWLS-RF increased by 2.5 times, with a growth rate of 153.58%, which was relatively higher than the state decadal growth rate of 30.65% (Table 2, Fig. 4). This sharp jump in the population of fringe area might

be due to the creation of new district Ri Bhoi, in 1992 around the NWLS-RF and declaration of village Nongpoh¹ as new town and headquarter for the new district. These changes brought a sharp jump in the population of the new town Nongpoh¹ from 2,326 in 1991 to 13,180 in 2001, with decadal growth of 466.6% (Table 2). This town is just 2.3 km from the boundary of NWLS-RF and is in the middle of two major cities, Guwahati and Shillong. Whereas, in 1981-1991, the Nongpoh¹ village showed a negative % growth rate of 31.46% (Table 2). The Nongpoh¹ town immediately became a centre of attraction for all types of opportunities, leading to a sharp increase in the town's population vis-à-vis the entire fringe area of the NWLS-RF. An exponential increase of 467% in the population was observed from 1991 to 2001, substantially decreasing to 29% by 2011. Nongladew²³ is another fringe area settlement that showed a high increase (407.46%) from 1991 to 2001. Whereas, during

1991–2001, the overall state population decreased slightly (Fig. 4). However, the increase of new settlements or villages in the fringe area in this decade was not much (Table 2).

During third decade, 2001–2011, the population in the fringe area of the NWLS–RF increased with 30.19%, which is nearly at par with the decadal population growth of the state due to normalisation with time and no further availability of population pull factors such as employment opportunities (Fig. 4). During this period, only two

new settlements, Nongwah Mawpnar²⁵ and Mawpyrhut¹¹ appeared in the fringe area (Table 2). The data shows that the population growth in the fringe area of the NWLS–RF is at par with the state population growth, except during 1991–2001 due to the re-organisation of districts and conversion of rural Nongpoh¹ to urban. To date, Nongpoh¹ is the only city/town out of 37 total settlements in the fringe area of NWLS–RF providing various facilities/services and considerably pulling the population from other fringe settlements, which are still rural.

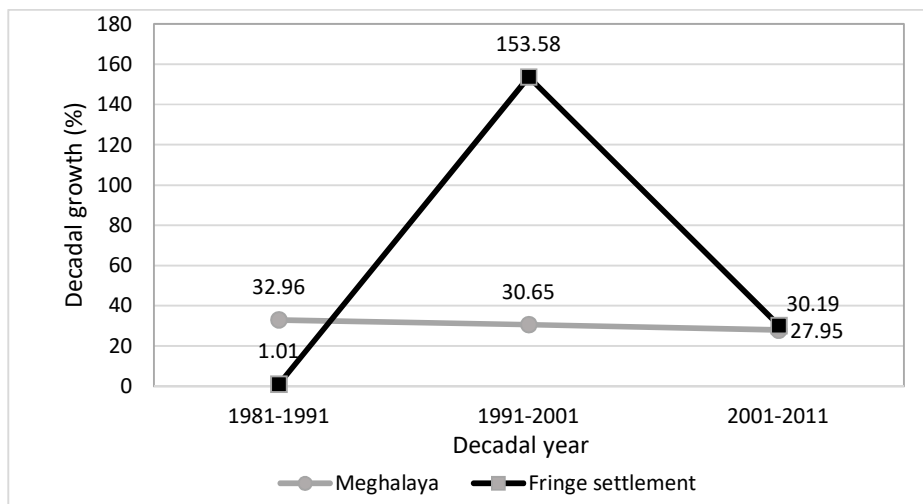


Fig. 4. Decadal population growth in Meghalaya and the fringe area of NWLS–RF.

Table 2. The population as per Census of India from 1981 to 2011 and aerial distance of the fringe settlements from the NH 6, SH 3, Other State Roads (Major District Roads, Other District Roads and Village Roads) and the boundary of the NWLS–RF.

Village / Town	Population				Population growth from 1981 to 2011 (in %)	The aerial distance of the settlements from the roads and NWLS–RF (in m)			
	1981	1991	2001	2011		NH 6	SH 3	Other State Roads	NWLS–RF
Nongpoh ¹	3,394	2,326	13,180	17,055	402.5	0	22,841	0	2,345
Pahamrinai ²	97	181	302	408	320.62	0	22,723	236	3,224
Umdihar ³	367	417	586	763	107.9	0	22,757	0	3,448
Iewisier ⁴	122	55	61	48	-60.66	2,977	15,140	0	1,116
Umsaw Nongkharai ⁵	100	169	266	503	403	0	22,160	0	4,343
Quinine ⁶	104	160	261	408	292.31	0	21,134	0	5,186
Umtasor Nongjyirmi ⁷	52	89	121	207	298.08	2,336	18,814	411	5,859
Maweithar ⁸	71	140	181	285	301.41	2,509	18,934	0	3,970
Umtasor Mawdkhar ⁹	538	766	1035	1,384	157.25	4,808	12,396	0	1,241
Nongrim Umksih ¹⁰	227	298	364	463	103.96	1,408	16,047	0	1,936
Mawpyrhut ¹¹	-	-	-	262	-	11,200	14,895	0	510
Nongmahir ¹²	-	228	367	485	-	6,959	13,890	0	865
Umdiker ¹³	234	188	329	615	162.82	13,568	9,788	0	330
Nongdiengngan ¹⁴	-	-	361	338	-	12,228	15,837	0	1,383
Umtngar ¹⁵	199	304	432	672	237.69	16,422	7,315	5,353	5,164
Umar ¹⁶	126	151	235	313	148.41	15,359	7,284	5,461	0
Umtasen ¹⁷	-	-	130	135	-	21,876	770	0	4,317
Nongwah Mawlein ¹⁸	489	612	832	613	25.36	20,220	2,635	683	2,376

Nongbirthem ¹⁹	242	289	386	531	119.42	3,038	20,098	0	2,911
Umsong ²⁰	820	379	612	815	-0.61	19,226	4,406	0	2,530
Nongwah Mawtamur ²¹	-	243	256	260	-	18,676	4,715	612	1,954
Nongkynrih ²²	130	104	144	225	73.08	14,220	8,913	4,176	0
Nongladew ²³	-	134	680	788	-	16,435	6,612	0	3,001
Jalithem ²⁴	18	23	40	195	983.33	16,635	8,231	0	3,684
Nongwah Mawpnar ²⁵	-	-	-	98	-	15,730	10,542	0	5,189
Tasku Rim ²⁶	278	183	276	356	28.06	11,617	12,990	0	3,620
Umsohma ²⁷	-	68	86	123	-	9,150	14,674	0	2,090
Lailad ²⁸	161	68	61	165	2.48	9,689	14,440	0	0
Umladoh ²⁹	77	48	62	115	49.35	587	17,423	0	100
Umdu ³⁰	121	187	263	425	251.24	3,220	22,107	0	2,045
Sohkhwai ³¹	348	465	694	520	49.43	3,598	21,752	0	2,044
Kongripara ³²	106	141	209	272	156.6	1,251	24,162	0	3,150
Narang ³³	455	230	381	530	16.48	534	24,868	0	3,010
Paham Mawlein 20 th Mile ³⁴	-	236	474	539	-	0	24,952	0	3,196
Umling ³⁵	760	786	1,037	1,296	70.53	0	23,646	0	300
Umling Lambrang ³⁶	117	167	236	339	189.74	0	23,198	550	230
Nongtyrlaw ³⁷	69	86	218	204	195.65	4,668	27,523	0	4,018
TOTAL	9,822	9,921	25,158	32,753	233.47				

INFRASTRUCTURE DEVELOPMENT IN THE FRINGE AREA

Generally, it has been observed that the increase in the population and settlements also brings various changes and infrastructural developments in the fringe areas, directly and indirectly affecting the wildlife inside and outside the PAs (Nishank, 2021). Roads are the only major developmental activities in the fringe region of the protected area (Fig. 1). These roads are classified into three categories- (i) National Highway (NH), (ii) State Highway (SH), and (iii) Other State Road (OSR) which includes Major District Road (MDR), Other District Road (ODR) and Village Road (VR) (National Informatics Centre, n. d.).

The NH 6 is located on the eastern side of the NWLS–RF. This road is one of the oldest not only in the state of Meghalaya but in the entire Northeast India, initially developed as a bullock cart road in 1864–1877 and then horse cart road in 1888 between Shillong and Guwahati (Das, 2021). During World War II, it was developed as a 'highway'; by 1981, it had already been declared a "National Highway" (Meghalaya Public Works Department, 1981). Previously, this Guwahati-Shillong Road was known as NH 40, which was renamed to NH 6 in 2019 after clubbing four National Highways (NH 40, 44, 154, and 54) into one single National Highway, that is NH 6, which connects three States- Mizoram, Assam and Meghalaya (Ministry of Road Transport and Highways, 2019). The Guwahati-Shillong segment of NH 6 became a four-lane road in 2016, linking the entire region, including Meghalaya, with other parts of the country (The Shillong Times,

2016). This NH 6 is one of the busiest roads in the region and passes adjacent to the NWLS with a minimum distance of 230 m near the fringe villages Umling³⁵ and Umling Lambrang³⁶ and passes through eight fringe settlements, including Nongpoh¹, the only town in the fringe area (Fig. 1, Table 2).

The SH 3 is located on the west side of the NWLS–RF with a minimum aerial distance of 5 km from the boundary of the NWLS–RF. The SH 3, initially an intermediate lane, was black-topped, improved in 2010, and converted to a double-lane road in 2020 (Meghalaya Public Works Department, 2020). The SH 3 runs through two districts of Meghalaya, Eastern West Khasi Hills and Ri Bhoi, eventually connecting with Assam. The nearest fringe village from SH 3 is Umtasen¹⁷, located at a distance of 770 m.

Numerous other roads (MDR, ODR, VR, etc.) connect the fringe settlements with other parts of the state/region. Only six fringe villages lack direct road connectivity. They are away from the roadhead with a minimum distance of 411 m (Umtasor Nongjyrmi⁷) to a maximum of 5,461 m (Ummar¹⁶, Fig. 1, Table 2). Other than these roads (NH 6, SH 3, and OSR) present outside the NWLS–RF, an internal patrolling road runs through the Reserved Forest, which has also become a commuting route for the local people and also disturbing the daily routine of the wild animals in the NWLS–RF.

The Nongpoh¹ settlement in the fringe area of the NWLS–RF is developing rapidly, from a humble

village before 1991 to a bustling city near the NWLS–RF. It is around 2.3 km from the boundary of NWLS–RF. It has all the basic infrastructural facilities of a middle-class town, like schools, hospitals, government offices, small business establishments, etc. All other settlements in the fringe area are still rural, where people mainly engage in agricultural activities.

Impacts of fringe population and infrastructural development in the fringe area on the wildlife of NWLS–RF

It has been observed that at the time of the creation of Yellowstone National Park in the United States of America in 1872, designated as the first legal well-defined protected area in the world, the world total human population was less than one billion, which had increased to more than 8 billion in 2023 (Gunther, 1994; United Nations Population Fund, 2023). The wildlife population, for example, the bison, for whom Yellowstone National Park was created, has reduced to 325 from more than 60 million before 1872 (Isenberg, 2001). However, the positive aspect is that Yellowstone National Park could conserve and multiply the bison population to thousands (Marmaduke, 2015). In the same way, after the creation of the NWLS, it has successfully conserved and protected wild animals of the region, Asian elephant (*Elephas maximus*) in particular (Meghalaya Forest Department, 2022^b). However, there are several negative and positive impacts of the fringe population and their settlements on the wildlife of NWLS–RF.

Negatives: The expansion of population, establishment of new villages and development of roads have led to the fragmentation of forest areas, which have created a nearly-isolated forest that limits the movement of large wild animals like elephants. The NH 6 has wholly halted the movement of wild animals on the eastern part of the NWLS–RF, and the SH 3 and OSR are limiting the movement of large wild animals on the west and north-west part of the NWLS–RF. It is also evident from the survey where respondents (5%) mentioned that elephants used to walk past the village Umladoh²⁹ five to eight years back, and they have not seen any elephant in the village since then. As agriculture is the main occupation practiced by these fringe populations, it has increased negative human-wild animal interaction due to the movement of animals from the forest to agricultural areas (Table 1). The people also entered the forest to collect NTFPs (Non-Timber Forest Products) and to celebrate the *Niangtaser* festival, which disturbs the wildlife in the region (Fig. 3).

Further, it was also observed that the internal patrolling roads are also being used for commuting by the local people, which disturbs wild animals, sometimes even killed for fear or as a hobby. Several studies have also indicated that the locals in Spain and Malaysia were also hunting for wild animals within the protected area as a hobby due to the accessibility being provided by the presence of roads (Saikim *et al.*, 2015; Perumal *et al.*, 2021; Carpio, 2023).

Positives: The fringe area of NWLS–RF experienced a gradual population growth (nearly natural) coupled with only a few settlements (nine only) coming up in 30 years. The presence of roads has provided rural communities to rely less on the NWLS–RF forest resources for their livelihood. The declaration of Nongpoh¹ as a district headquarters and a town in 1992 has also caused a significant change in the socio-economic structure of the fringe area (Table 3). A substantial decrease in the practice of agriculture was observed, which may have been influenced by the presence of the NH 6. Further, this leads to less negative interaction with wildlife within the PA. Accessibility to employment,

education and health facilities in Nongpoh¹ has also become possible due to the presence of Other State Roads, State Highway 3 and National Highway 6.

The presence of roads has also led to population migration from the rural settlements near the NWLS–RF with no proper road connectivity, thereby decreasing the population in these fringe villages. Records of rural migration for the providing jobs, education, health facilities and other opportunities to semi-urban or urban areas due to roads near a NWLS–RF are also known worldwide (Perumal *et al.*, 2021).

Table 3. Changes in the rural agricultural sector of the fringe settlements of the NWLS–RF. VNE= Village not established

Settlements	Main cultivators (%)			
	1981	1991	2001	2011
Nongpoh ¹	12	11	8	9
Pahamrinai ²	48	0	29	27
Umdihar ³	37	0	10	6
Iewsier ⁴	33	22	0	25
Nongkynrih ²²	57	59	38	13
Nongwah Mawpnar ²⁵	VNE	VNE	VNE	27
Tasku Rim ²⁶	27	53	45	28
Umsohma ²⁷	VNE	46	37	47
Lailad ²⁸	32	69	7	0
Umladoh ²⁹	18	60	0	57
TOTAL	18	15	9	10

CONCLUSION

The success of conservation and wildlife protection within a protected area dramatically depends on the pressure from fringe populations and their settlements. According to our findings, there has been a gradual population growth in the fringe area of the protected area. The increase in population was mainly observed along the roadside. Nongpoh¹ showed the highest population growth among all the settlements because it was declared a town and district headquarters in 1992. The town is on a national highway between two major cities, Shillong and Guwahati. There are also numerous infrastructures and facilities like hospitals, schools, government offices, and other business establishment. This indicates that an urban area and road proximity can influence population growth. It is therefore suggested to manage the growing population by developing infrastructure and other facilities near Nongpoh and other places that are more than 5 km away from the NWLS–RF to increase the out-migration of the fringe population so that wildlife in the region is not affected due to increased pressure from human for land and natural resources. Maintaining wildlife populations is critical in an era when there is a constant threat from humans regarding space. In that case, the skill of the fringe population should be enhanced in various other fields and generation of employment opportunities to decrease dependency on forest resources and traditional agricultural activities.

Another significant observation in this study is that the fringe population still has a very high positive

perception and attitude towards the wildlife of the protected area, even though they are greatly affected by declaring their primary source of livelihood as Nongkhylllem Wildlife Sanctuary in 1981. This positive perception and attitude of the fringe population should be maintained by introducing alternative livelihood avenues such as food and fruit processing units like pineapple and coconut processing units. Further, the wildlife management authorities may actively involve the fringe population in conservation efforts to maintain their positive attitude and perception and consider themselves protected area stakeholders.

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