

Whether is Flood Doom or Boon for Kaziranga National Park of Assam, India?

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JGEESI/2022/v26i430346

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/87014>

Original Research Article

Received 06 March 2022

Accepted 09 May 2022

Published 13 May 2022

ABSTRACT

The Kaziranga National Park of Assam is located in the floodplain ecosystem of the Brahmaputra River and hence the flood is the annual feature of the park. Amidst of it, the management for survival of the park along with its spectacular thriving is admirable. However, the perennial flood hurts the park at large carrying tragedies of different kinds such as land erosion, siltation of the water bodies, habitat degradation, damage of physical infrastructure, and exacerbate the accidents of the animals on the NH-37 and the poaching of the helpless animals. Conversely, the flood paybacks the park through nourishing and reviving its ecosystem in several ways such as refill the wetlands, refresh grasslands and remove invasive species, on annual basis. These, otherwise, would entail harder job and hence, a huge cost for the park management. Against this backdrop, an attempt has been made to examine to what extent, the flood is a doom for the park, and is a boon in the park through investigating and critically analyzing of the effects of flood on this world famed wildlife venture. Moreover, how the park authority has managed the flood season to mitigate its adverse outcomes has been examined in this academic work.

Keywords: Flood; doom; boon; habitat; wetland; grassland; poaching.

1. INTRODUCTION

Kaziranga National Park (KNP) with areas of 430sq.km spreading over two districts-Golaghat

and Nagoan is situated in the midst of Assam, a flood prone Indian state. The park acts as a sandwich between the Brahmaputra River on the northern and the Karbi Anglong Hills on the

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southern. Hence, for its strategic location in an influential area of the Brahmaputra River, the ecosystem of the park instead of being solid land mass-based is largely floodplain/riverine, which requires sufficient water on regular basis for its unique survival¹. The common view on flood among the people of Assam is that the flood is one of the worse phenomena for its destructive nature. However, this perception on floods does not seem to be in vogue, particularly for the KNP. Though the flood causes the deaths of animals and degrades the habitats, it acts as means to support the ecosystem of the park. For the park, flood acts as lifeblood in refreshing its landscape containing a mix of the grasslands, wetlands and semi-evergreen deciduous forests. In an herbivore-dominated landscape of Kaziranga, the maintenance of the grasslands and wetlands is highly essential job, which the floods accomplish naturally on annual basis. Moreover, the floods washing out the invasive flora such as water hyacinth and Mimosa perform another urgent task for the park².

Despite such virtues of the floods in the park, the floods in the park are often recognized as one of the major challenges/ threats to its biodiversity conservation and sustainability. No doubt, the park suffers much from the devastating effects of the perennial floods of the mighty river Brahmaputra and its tributaries. In a fresh wave of floods, around 85 percent of total landscape of Kaziranga National Park and Tiger Reserve (KNPTR) gets submerged into water level. Barring 2018, the park experienced high level of floods in the years between 2016 and 2020 that had submerged more than 60 percent of the park's area [1]. The floods of 2012 took the lives of a large number of animals in the park that stood at about 1% of the total wildlife population in the park. Floods making a loss of permanent habitats compel the animals to move out of their reserved areas into human habitation, which make them vulnerable to poachers and human-animal conflicts.

However, defending against such drawbacks of the floods, the park officials urge that the floods usually take the lives of the infants, aged and sickness animals, which are, in practice, the

looser in the battle of survival for fittest. Again, all floods do not make casualty of the wildlife that depends mainly on the strength and direction of floods. The park has a number of higher elevation areas that may act as shelters for the animals during the strong floods³.

Hence, KNP are naturally bound to take on comprehensive shocking effects from the perennial floods. Parallel to it, the park is fortunate to receive immense benefit from the floods. So, the floods in KNP can be more appropriately described as a necessary evil. However, to what extent, the floods are doom (disaster) and boon (windfall) for the park has been understood only partially. Whether the floods act as more doom or more boon for the park is not understood properly. So, in this academic work, an attempt has been made to examine the incidence and severity of the flood for the park .i.e. the floods as doom for the park, and benefits accruing from the floods i.e. the floods as boon for the park through investigating and critically analysis of the effects of this annual event on the park. Moreover, it has been examined how the park authority has managed this necessary evil to lessen its adverse outcomes, and what measures required to be adopted to derive the favourable outcomes more.

1.1 Review of Literature

A number of authors and researchers including the management officials and the stakeholders of the park have studied varied issues and problems of KNP from time to time. Some authors have outlined that though the conservative practices in KNP have disrupted the inherent livelihood pattern of the local communities hinged largely on the park's natural resources, the local community have participated to park's conservative practices in admirable manner, and in turn, the park have also provided them varied employment opportunities [2]. The researcher, Daisy Das in her study has examined the attitudes of the local people towards the conservative efforts of the park, and found the distress and contest towards such practices on the part of many people. The displacement, deprivation from resources, damages of crops and livestock by wild animals

¹Tora Agarwala. *Why annual floods are essential for the survival of Kaziranga National Park, Explained Desk*, Guwahati; 2020.

²Nabarun Guha & Sahana Ghosh: *Wildlife and people work together during Assam's annual tryst with floods*; 2019. Available: <https://india.mongabay.com/2019/07/wildlife-and-people-during-assams-annual-tryst-with-floods/>

³Anshul Srivastava. *Can A Flood Be Beneficial? Yes, when it's At the Kaziranga National Park at Assam!*. Available: <https://www.thebetterindia.com/13673/benefits-of-flood-kaziranga-national-park-assam/>

are attributed to be the root cause of such agony among the local people. Many of the local people are found to be apt to resort some unfair and hostile affairs. The author has suggested for extension of tourism/allied activities and local community welfare measures at the adjacent areas of the park [3]. The researcher, Mayuri Gogoi has identified some threats to the biodiversity conservation practices in KNP. These are- the loss of habitats due to uncontrolled encroachment, dangerous waste from the nearby standing Numaligarh Refinery Limited (NRL) and man-animal conflicts [4]. Jasmine Bharali et al in their study on the wetland ecosystem of the KNP, have examined the physio-chemical features of the water and soil of the wetlands, rate of primary production of these water bodies, and conservation practices adopted for the same. They have found the wetland ecosystem of the park as healthy and fair for biodiversity [5]. The author, A. Saikia has highlighted how through a series of change in paradigms of the wildlife conservation in KNP, the park is able to achieve its present high status of world heritage site from the earlier game sanctuary. Again, he has opined that more of the conservative strategies and practices in KNP relates to social and historical aspects rather than the technological aspect [6]. Investigating into the conservative attitudes and awareness among the people at the vicinity of KNP, some researchers have found a high dispersion on the same. The diverse demographic and socio-economic status of the local people are the root causes of it. Most of the local people surveyed are found to be aware of the conservative practices in the park. Many of them are not in favour of the conservative practices, mainly due to their threats on losing crops to wildlife and being conflicted with them. For conservation and development, the authors have suggested for adopting micro-site planning approach in the areas characterized by high ethnic diversity, high density of population, and land-dependent large mammals posing economic risks. Further, they have suggested for improving education among the local people, adoption of suitable development schemes in such areas and participatory approaches to resource management [7].

Patnaik et al in the study has pointed out several adverse outcomes that the perennial flood of the Brahmaputra River brings to the mammals in the park and poses challenges to the park management. Such misfortunes carried by the floods are the displacement of the mammals

from their regular habitats, victimization at the hands of poachers and at the heavy vehicles in NH-37 crossing throughout the park [8]. The author, Beejata Das has examined the effects of the floods on the sustainability of one horned Rihno and identified it as one of the major challenges of the park. In the study, she has found a number of harmful effects that the floods have imposed on the park such as loss of wildlife, shortage of fodder and malnutrition, soil erosion and damage of infrastructure. Besides, the author has pointed out several causes of the annual floods in the park such as heavy monsoonal rains, deforestation and existence of the park in riverine areas [9]. Rabin Sharma, one research officer of KNP has opined that though the park has to bear a sizeable loss in its biodiversity annually due to the floods, the floods are highly essential for smooth functioning of the ecosystem of the park. The floods naturally washing out the invasive species and cleaning out the water bodies, however, do important jobs for the park [10]. P Sivakumar, Director of KNP has highlighted the hazards that the recurring floods bring to the wildlife and the park authority on an annual basis. During monsoon, the entire areas of the park barring some high grounds get submerged under the over flowing water level of the Brahmaputra River. The perennial floods leading to land erosion result in degradation of habitats for the animals. The floods increasing the interaction between human and animals intensify the conflict between the two. During floods, the animals that venture out of the park are at hazard in the forms of the fatal accidents on NH-37 or the easy poaching due to their vulnerability. Moreover, the floods frightening and agitating the animals incline them to behave aggressively that threaten the lives of forest frontline staff while they are patrolling. During floods, the wild animals confront different kinds of stress such as physical, and behavioral; and many, due to the shortage of the fodder, are victim of nutritional stress [11].

Assam is naturally a flood-prone state due to its strategic geographical setting and location, heavy monsoon rainfall and erodible geographical formation⁴. Being located in such a flood prone region and also in a floodplain ecosystem of the mighty Brahmaputra River, the recurrent floods are the integral feature for the park. Moreover, during monsoon, the water

⁴ Available: <https://www.sentinelassam.com/editorial/flood-in-assam-causes-remedies-490970>, as retrieved on 5th April, 2022.

flowing through the Karbi Anglong and Naga Hills through various channels and streams submerges the low laying areas of the park⁵. However, several natural and artificial factors are in vigour that causes floods in the park with varied intensity almost on annual basis. Floods in KNP hinges largely on the intensity of rainfalls in the catchment areas of the Brahmaputra and its tributaries. During monsoon, Assam gets heavy rainfalls that raise the river-bed of the Brahmaputra River. Rising water level of the Brahmaputra River enters into the park via the northern side and inundates the entire areas of the park gradually.

The Park is strategically located in a riverine area under the influence of the Brahmaputra River to the north and its three tributaries- Dhiplu, Mora Dhiplu on the south and Mora Dhansiri on the east. However, Dhiplu River flows throughout the park, and hence, influences the ecosystem of the park largely acting in a similar manner what the water bodies of the park do. Dhiplu River usually submerges the park when the Brahmaputra flows above the flood level⁶. The high intensity earthquake of 1950 and the gradual silt deposition have raised the river-bed of the Brahmaputra. These make this mighty river shallower and wider, for which the existing streams of the river are not able to carry the sediments during monsoon that results in flooding. During May to August in monsoon, the occurrence of heavy rainfalls overflows the water level of the Brahmaputra River which results in a heavy flood in KNP. Massive deforestation in the upper catchment areas of the Brahmaputra River due to the human activities and frequent cutting of hill slopes for shifting cultivation in the hilly areas intensifies the process of runoff and soil erosion. The sediments of the eroded soil with water flow copiously from the hilly areas to the rivers and streams. This makes shallower the rivers that contribute to the flooding. Sometimes, the smash of dikes on the eastern side of KNP and water released by dams upstream result in sudden rise of the water level that generate flood problem in the park.

Hence, in examining varied issues and challenges of KNP, some authors have examined the attitudes of the local people towards the conservative practices, some has

⁵ Available:
<https://abhipedia.abhimanu.com/Article/State/NDQ4MwEEQ QVVEEQVV/Kaziranga-National-Park-and-Flood-Assam-State>, as retrieved on 5th April, 2022.

⁶ *ibid*

identified various threats to the conservation practices and some others have studied the wetland ecosystem of the park, climate change and causes of the recurrent floods in the park. However, there is not a common consensus among the authors and hence, is a confusion on whether the flood in the park is a doom or a boon. For some, it is a major challenge to the park to its biodiversity conservation and sustainability, and for some others, it is life blood for the park for smooth functioning its unique ecosystem. So, such confusion on the floods in KNP has been tried to examine and hence, contain through investigating the overall effects of the floods on the park in this academic work. This has been done through analyzing the effects of the floods on the park from two opposite angles-doom (cost) and boon (benefit). Again, what strategies and measures the park management has adopted to mitigate the harshness of the floods, and hence, how the park has managed the flood seasons has been examined in this work.

1.2 The objectives of the study are to examine the adverse effects of the floods on the park, the beneficial effects of the floods on the ecosystem of the park and the strategies adopted by the park authority to manage the flood seasons.

1.3 Research Questions:

- i. Has the animal deaths on NH-37 due to the floods declined during the study period?
- ii. Is there any significant association between the addition of new highlands and animal deaths due to the floods?

2. RESEARCH METHODOLOGY

The methodology of the study contains mainly the area of the study, analytical and data framework.

2.1 Area of the Study

The study area covers the geographical areas under Kaziranga National Park. The locations of the study include mainly the areas under the four ranges of the park (Agoratoli, Kohora, Bagori & Burapahar) in two divisions(out of three)-Eastern Assam Wildlife Division& Nagaon Wildlife Division.

The logics behind selecting KNP as the study area are as follows. This magnificent wildlife hot

spot is the home to 80 percent of the world's total one horned rhinoceros, world's largest population of Asiatic Wild Buffalo and Eastern Swamp Deer:

- i. It is only the habitat on earth that provides space to the big five together (shown in Table-1).
- ii. The park has recorded 34 species of mammal and 480 species of birds, out of which 18 birds are recognized as globally threatened.
- iii. The park has a rich flora ecosystem that contains semi evergreen forest, elevated grounds, streams, marshes, grasslands, plains and tall elephant grass.
- iv. The park has a unique wetland ecosystem covering 7% of the total areas of the park, which is the habitat to varied mammals, amphibians, birds, reptiles and fishes.
- v. The park has drawn a large volume of tourist from different parts of the world that contributes to the government treasury much since a long.
- vi. It has lured 82% of the total tourists visiting national parks and sanctuaries in Assam⁷.

2.2 Analytical Techniques

For analyzing the animal deaths on NH-37 during the floods, the trend line analysis has been done. For examining the efficacy of the artificial highlands in reducing animal deaths during floods, the techniques of correlation coefficient and chi-square have been used.

2.3 Data

For examining the varied effects of floods on the wildlife, ecosystem and management of the park, the required information/data has been collected from both primary and secondary sources. Primary data on the animal casualties due to the floods and animals rescued has been collected through personal interview with the management officials of the park. The data/information on other outcomes of the floods such as land erosion, siltation and refreshment of water bodies, washing out invasive species, migration of animals and poaching has been collected from a number of secondary sources as follows-

⁷ Ratan Bharali Talukdar: Kaziranga attracts 82 percent of national park visitors in Assam, NEZINE; 2016. Available: <https://www.nezine.com>

- i. Office of the Divisional Forest Officer, Eastern Assam Wildlife Division, Bokakhat.
- ii. Detailed Report on issues and possible solutions for long term protection of Rhino in Kaziranga National Park, Director of KNP, 2004.
- iii. UNESCO's Initial Management Effectiveness Evaluation Report on KNP, 2003
- iv. UNESCO's Technical Report No-4 on KNP, 2005.
- v. News Papers such as Times of India, India today and the news mill.
- vi. Websites such as <https://india.mongabay.com> ; <https://www.thebetterindia.com>; <https://nenow.in/north-east-news/assam> ; www.kaziranga-national-park.com/blog/ and www.greentribunal.in

3. DISCUSSION AND RESULTS

3.1 Adverse Effects of the Floods on the Park

The perennial flood that carries disaster to the wildlife and park management to a large extent is one of the major challenges of the park to its biodiversity conservation and sustainability. However, the high intensity floods causing the death of wildlife, damage of infrastructure and disorder of the management staff become a curse/doom to the park.

3.1.1 Animal casualty

The recurrent annual flood in the KNP devastating the habitats of the animals makes them sufferer to a number of harsh outcomes, which bring either deaths or heavy injury to these vulnerable animals. The number of animal deaths has reached its maximum of 812nos at the flood of 2012(Table-2), which is around 1 percent of the total animal of the park of that year. Out of 812 nos, the deaths of Hog Deer has stood at the highest of 647 nos (79.68%). Next to Hog Deer, the death of wild boar is 2nd position with 52nos followed by rhino with 47nos (Table-3). Then, the animal casualty tends to decline and reaches the minimum at 21nos in 2015. In that year too, among the wild animals, deaths of Hog Deer was the highest at 17nos (Table-3). But again, in 2016, the animal casualty due to floods has increased to 475 nos, out of which the highest 380 nos of Hog Deer reached their deaths, followed by rhino with 32 nos (Table-3). Then, it marginally declined to 291nos in 2017, to

223nos in 2019 and 157nos in 2020. In each of the reported year, among all the animals, Hog deer is the largest in number reaching deaths during floods (Table-3). Hence, the floods in the park take a heavy toll on the wildlife. However, the floods cause the deaths of the wildlife in varied forms such as drowning, vehicle hit, snake bit, stuck in mud and poaching.

3.1.1.1 Drowning

During high intensity floods, except some highlands, the entire area of the park gets inundated that takes the lives of many animals at drowning. As per the park officials, most of the animals getting deaths under the flooded water are usually the losers in the battle of survival for fittest such as infants, aged and sickness ones. Barring 2018, for the period 2012-20, out of total 2044 animal deaths during the floods, 1798 nos of animal have got deaths at drowning, indicating much higher percentage(87.96%)(Table-2). In 2012, out of the maximum animal deaths (812nos), the largest number of deaths happened at drowning (748nos) indicating a remarkable rate of 92.12 % (Table-2). In fact, barring 2013 and 2015, the drowning has been the dominant form/cause of the animal deaths during the period 2012-20 (Table-2).

3.1.1.2 Accidents at NH-37

During high intensity of flood that raises the water level up to a certain level, the animals in the absence of safer grounds have no way but to rush to the elevated grounds at the Karbi Anglong hills for safety. In fact, the animals adapt to the floods by moving to the elevated grounds of Karbi Hills for finding their temporary refuge since a long. Since early times, for the wildlife, Kaziranga and Karbi Anglong have been a single landscape. Importantly, NH-37 cross through the park running parallel on the southern boundary of the park, and divides the landscape between riverine areas of the Brahmaputra on the north and the elevated Karbi Anglong hills on the south. So, it is highly essential to maintain the animal corridors safe and undisturbed through which the animals usually cross the NH-37. However, several animal corridors on NH-37 have been observed to be garroted by heavy traffic since the last few decades. Moreover, mushrooming of the commercial establishments such as restaurants, hotels and dhaba nearby the animal corridors; and some other human activities such as tea gardening, rock mining and

quarrying have blocked the animal corridors. The national green tribunal has reported the existence of a large number of dhabas and restaurants in the animal corridors near the park⁸.The Comptroller and Auditor General (CAG) report, 2014 on KNP has pointed out the business operation by around 29 commercial establishments within the Bokakhat Circle and 62 ones in the Kaliabor circle, just a few kilometers from the park boundary.

Hence, the wild animals that venture out of the park during the floods get their deaths at the hit by the fast vehicles while attempting to cross NH-37. In 2012, the animal deaths at vehicle hit on NH-37 stood at highest (45nos). However, it tends to decline marginally over the successive years. The death of animals at vehicle hit was lowest at 03 nos for 2014 and 2017. Barring 2018, a total of 172 nos animal died at vehicle hit on NH-37 during the floods for the period 2012-20(Table-2). The trend line (red line) indicates a decline in the animal deaths on NH-37 up to 2016 and a gradual rise in it afterwards (Fig. 1).

3.1.1.3 Intensify poaching

The flood intensifies the poaching of wildlife in the park in several ways. The floods making loss of habitats compel the animals to wander in search of safe grounds. Since the early times, the flood affected animals use to move to the elevated grounds at Karbi Anglong, where they are often vulnerable at the hands of poachers. Moreover, the floods causing the fodder scarcity among the animals push them to move to high grounds on the southern side of the park in search of food. The park officials opine that the wild animals are often at a risk of poaching when they venture out of the park either for safety and fodder during the floods⁹. For the forest staff, it becomes a challenge to save the wildlife from the poachers during the floods. Some of the park officials urge that for poachers, especially of rhinos, the flood season has been a much advantageous juncture¹⁰.

⁸ First Spot. Indian News, New Delhi, India; 2015.

⁹ Hemanta Kumar Nath. Forest staff face challenges in saving wild animals from poachers during floods in Kaziranga National Park, India today, Guwahati; 2020. Available at <https://www.indiatoday.in/india/story/assam-flood-kaziranga-national-park>.

¹⁰ Sumir Karmakar. Flood in Kaziranga is a golden time for poachers, DHNS, Guwahati; 2019. Available: <https://www.deccanherald.com/national/east-and-north>.

Table 1. General characteristics of Kaziranga National Park

Sl. No	Attributes	Information/Data
1	Status	National Park , World Heritage Site & Tiger Reserve.
2	Location	Between 26°30' N and 26°45' N latitudes, and 26°30' E and 93°40' E longitude within two districts of Assam- Golaghat and Nagoan.
3	Area	430sq.km.
4	Conservative milestones	Reserved Forest in 1904, Game Sanctuary in 2016, Wildlife Sanctuary in 1950, National Park in 1974, World Heritage Site in 1985 and Tiger Reserve in 2007.
5	Ranges	Four(Agoratoli, Kohora, Bagori & Burapahar)
6	Divisions	Three(Eastern Assam Wildlife Division, Biswanath Wildlife Division & Nagaon Wildlife Division)
7	Major fauna	Rihno, Wild Buffalo, Wild Boar, Swamp Deer, Hog Deer, Hog Badger, Pelican Bird, Sambar, Porcupine, Python, Tiger, Elephant and Turtle
8	Big Fives	Rhino, Swamp deer, Asiatic wild Buffalo, Asiatic Elephant and Royal Bengal Tiger.
9	Major Flora	Alluvial savanna woodlands, tropical moist mixed deciduous forests, elephant grass, spear grass, cotton tree, Indian gooseberry, kumbhi tree, sugarcane and swamplands.
10	Wetlands	92 nos (permanent); Cover around 7% of the total areas of the park.
11	Floods	Perennial in nature; Submerged 60% to 95% of the total areas of the park.
12	Influential Rivers	Brahmaputra, Diphlu, Mora Dhiplu & Mora Dhanshiri

Table 2. Animal casualties in KNP and Adjacent Areas due to floods during 2012 to 2020

Casualties	Drowning	Vehicle hit	Others	Total
Year				
2012	748	45	19	812
2013	13	13	00	26
2014	26	03	10	39
2015	07	09	05	21
2016	449	15	11	475
2017	284	03	04	291
2019	189	17	17	223
2020	82	22	53	157
Total	1798	172	119	2044

Source: Office of the Divisional Forest Officer, Eastern Assam Wildlife Division, Bokakhat.

Table 3. Casualty of the different animals due to the floods during 2012-20

Year	Rhino	Swamp Deer	Hog Deer	Water Buffalo	Sambor	Wild Boar	Porcupine	Elephants
2012	47	14	647	10	27	52	06	02
2013	03	02	17	00	00	01	00	03
2014	02	01	20	02	00	03	00	01
2015	09	01	11	00	00	00	00	00
2016	32	15	380	09	06	21	08	00
2017	24	04	232	05	14	04	01	05
2019	21	07	153	04	13	20	04	01
2020	19	04	109	06	01	12	04	01

Source: Office of the Divisional Forest Officer, Eastern Assam Wildlife Division, Bokakhat.

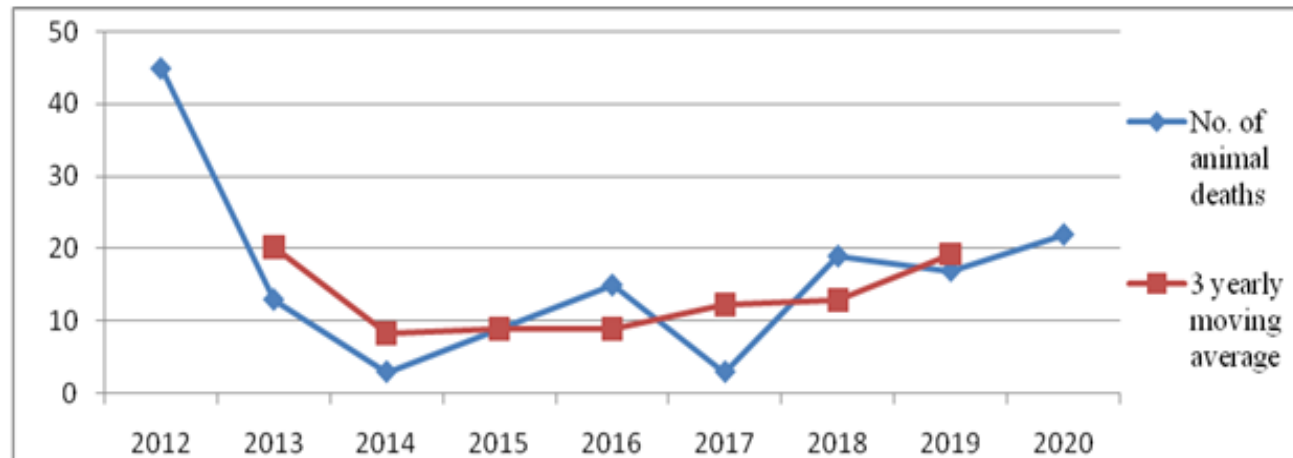


Fig. 1. Trend of animal deaths on NH-37 due to the floods for the period 2012-20

Source: Drawn from the data set on vehicle hit as given in table-2. Data for 2018 has been estimated by the author

3.1.1.4 Intensify human-animal conflict

The usual conflict between wild animals of the park and human at the fringe areas of the park arise, mainly due to the human activities nearby the animal corridors and damage of crops and other properties by wild animals of the park. Apart from these, the floods cause several adverse outcomes to animals that make them aggressive. However, the flood carries physical and behavioural stresses to the animals as it makes loss of their habitats, creates food scarcity, frighten and agitate. During the monsoon, to escape from the floodwater, the animals, mainly the large herbivours of the park move to the human residences or through the human-dominated spaces that leads to a conflict between the human and wildlife¹¹. Traditionally, the animals use to move to the high grounds at Karbi Hills during the floods. However, since the last few decades, the human settlement in the Karbi Hills has been increasing that leads to human-animal conflict. Moreover, the blockage of the animal corridors along the national highway due to the increased human activities is another major cause of such conflict. The increased human activities have resulted in encroachment of the space, which are, in fact, the animal corridors in past. However, the increased encroachments of the animal corridors leave a little space for the animals through which they used to move out to escape the floods. Notably, a tea garden at Kanchanjuri has blocked the animal corridor using the barbed wires, which acts as an impediment to the accessibility for the park' animals.

3.1.1.5 Others

Snake bite and stuck mud are the two other factors that cause the deaths of animals during floods. However, these two factors have not been found to be much influential during the study period. In 2020, having trapped into immovable mud, one rhino had been found to get the death¹².

3.1.2 Efficacy of the artificial highlands in reducing animal deaths during floods

For protecting the wildlife from the devastating floods, the park has a number of natural and

artificial highlands, which act as the shelters to the vulnerable animals during the floods. As per the park officials, in 2016-17, additionally 33 artificial highlands have been built inside the park, which in combination with the existing 111 highlands in 1990s has increased the total number of such elevated grounds in the park to 144 nos now. For examining the efficacy of the highlands in reducing the deaths of animals during floods, at first, the coefficient of the correlation (r) between the highlands and animal deaths has been determined. It has been found to be negative and much small at -0.096 (calculated from Table-4). The negative sign of ' r ' indicates that the increase in highlands has reduced the deaths of animals due to the floods during the study period, but much small value of correlation coefficient states a weak association between the two. Hence, through correlation study, it has been found that the highlands assist in reducing animal deaths during floods only to a small extent.

Further, for examining the efficacy of the newly built 33 highlands inside the park in 2016-17, chi-square test has been done. Through it, the significance of the association between the addition of 33 highlands and animal deaths during floods has been examined. For it, the seven major animals affected by the floods, namely rhino, swamp deer, hog deer, water buffalo, wild boar and elephants have taken into account. For examining the efficacy of the 33 new highlands, the year of 2017 has been taken to be the demarcating line. The number of animal deaths due to the floods and the number of animal remaining alive (only for seven ones taken in the present study) has been estimated for two periods – prior to the addition of 33 highlands and after the addition of new highlands. For it, the required data on the population size of these seven animals and number of their deaths due to floods have been collected from office of the Divisional Forest Officer, Eastern Assam Wildlife Division, Bokakhat. For this study, a period of ten years (2012-21) has been considered- the last five years prior to the addition of 33 highlands (2012-16) and the five years subsequent to the addition (2017-21). For one degree of freedom at 5% level of significance, the calculated value of chi-square is found to be 63.94, which is much greater than the table value of chi-square (3.84) (calculated from table-5). This urges to reject the null hypothesis of having not significant association between the addition of 33 artificial highlands and the animal deaths due to the

¹¹ Sahana Ghosh. To escape floodwaters, Kaziranga's large herbivores risk moving through human-dominated spaces: study, Mongabay, India; 2021. available at <https://india.mongabay.com/2021/08/>

¹² Flood Report-2020, Government of Assam, Kaziranga national park & Tiger Reserve, Bokakhat.

floods. Hence, the addition of newly built 33 highlands inside the park has a significant influence in reducing the animal deaths due to the floods during the study period.

This finding is in conformity with the park officials who view that the decline in the death of animal is attributed to the construction of 33 new highlands inside the park. This proves that during floods, the animals, especially rhino, water buffalo, hog deer and swamp deer take shelter in these highlands. However, at present circumstance of the increased number of wildlife, more of such artificial temporary refuges are required in the park for accommodating all of them. Moreover, the dilapidated condition of the older ones has further intensified the demand for construction of more of such refuge.

In contrast, some park officials and experts view that the construction of more highlands without unscientific planning may disturb the natural ecosystem of the park fastening the process of ecological progression. Under such circumstance, the floodplain ecosystem of the park may convert into a solid land-mass based /drier ecosystem, which is not a favourable habitat for the important fauna, particularly for rhino, swamp deer and water buffalo¹³. Some experts opine that the construction of more highlands may change the hydrology of the park. Since such efforts diverting the course of the flood water to a large extent has a strong potentiality in impeding the natural refreshing mechanism of the ecosystem of the park. In the absence of such natural cleaning mechanism provided by the floods, the higher accumulation of water hyacinth in the water bodies would degrade such habitats for the wildlife. Moreover, the change in hydrology may pave the way to grow the unpalatable plant species in place of the palatable grasses, delicious foodstuff for the herbivours. So, instead of constructing the highlands in the core areas of the park, these should be built at the fringe and addition areas.

Again, one wildlife warden views that instead of taking such suddenly built artificial refuge in confidence, some animals use to migrate to the earlier natural elevated grounds of Karbi Anglong¹⁴. One research officer of the park urges

that the necessity of the highlands arises mainly due to the blockage of the natural corridors via NH-37, through which the animals move to the elevated grounds at Karbi Hills. If these natural corridors had been opened, the need for highlands would not arise¹⁵.

3.1.3 Land erosion

The perennial floods of Brahmaputra River eroding incessantly the river bank largely on the northern boundary of the park cause a heavy loss of the landscape of the park. The intensity of land erosions is found to be severe near Erasuti and Moklong Camps of the park. However, the erosion points change owing to the change of course of the river. As per a report on KNP in 2001, KNP is incurring a loss of land by 0.7 sq. km in almost annual flood by Brahmaputra River. In 1998, the area of the park was estimated to be only 40,790 hectares against the notified area of 42,993 hectares in 1974. The authors, J.N. Sharma and S. Acharjee in their study had found the floods causing a heavy land loss of the park particularly on the east-north eastern and western sides. During 1912-1916 to 1972, the park had incurred an estimated land loss of 84.87 sq. km, which has decreased to 44.7 sq.km for the period 1972-1998, and to 20.41 sq.km during the period of 1998-2008. Hence, the park had lost a large volume of land (149.98 sq. km) for the period from 1912-1916 to 2008, which is amazing (Table-6). Importantly, the relentless land erosion consequent upon floods has reduced the size of habitation land for the wildlife in the park.

3.1.4 Siltation

The recurrent floods silting the water bodies / wetlands have contracted the size and deepness of these important habitats, which are the integral parts for the survival of many important fauna such as rhinos, wild buffalos and exotic bird species. Moreover, the floods depositing sand in short grass areas have also degraded the suitability of such areas for the herbivorous.

3.1.5 Reduce the habitats

Flood eroding the river bank and hence, landscape of the park and silting the water bodies has resulted in contraction of the habitats for the wildlife in the park.

¹³Sivakumar P. *Wildlife and people work together during Assam's annual tryst with floods, KNP, Wildlife Tourism, Mongabay, Guwahati, India; 2019.*

¹⁴Uttam saikia. *Flood triggers animal migration from Kaziranga National Park(edited by Naresh Mita), Times of India; 2019. Available: <https://timesofindia.indiatimes.com/city/guwahati/flood-triggers-animal-migration-from-kaziranga-national-park/>*

¹⁵Abdul Gani. *The news mill, voice of northeast India; 2020. Available: <https://thenewsmill.com/wildlife-experts-say-no-to-artificial-highlands-at-kaziranga-national-park/>*

Table 4. Number of highlands and animal deaths due to the floods during 2012-20

Year	No. of Highlands	No. of Animal Deaths	Year	No. of Highlands	No. of Animal Deaths
2012	111	812	2016	111	475
2013	111	26	2017	144	291
2014	111	39	2019	144	223
2015	111	21	2020	144	157

Source: Office of the Divisional Forest Officer, Eastern Assam Wildlife Division, Bokakhat.

Table 5. Association between animal deaths and addition of artificial highlands

Animals	No. of deaths due to floods	No. of alive & escape from floods	Total population
Prior to the addition of highlands(2012-16)	1,338	56,861	58,199
After the addition of highlands(2017-21)	1,098	64,769	65,867
Total	2,436	1,21,630	1,24,066

Source: Office of the Divisional Forest Officer, Eastern Assam Wildlife Division, Bokakhat.

Table 6. Size of Land lost in KNP due to the floods during 1912-1916 to 2008

Year/ Period	Land Lost (sq.km)
1912-1916 to 1972	84.87
1972 to 1998	44.70
1998 to 2008	20.41
Total	149.98

Source: M K Jadava(5th August,2014): Detailed report on issues and possible solutions for long term protection of the greater one horned rhinoceros in Kaziranga National Park, Government of Assam, Kaziranga National Park,pp.46

3.1.6 Damage of the infrastructure

The perennial floods damaging and dislocating the infrastructure of the park such as roads, bridges, camps and poles, make heavy strain on the resources of the park.

3.1.7 Anxiety for the park management

The floods put the entire park in a state of disorder and confusion. It creates an anxiety for the park management putting them in a level of high alert for extended period¹⁶. However, the park management requires preparing suitable strategies prior to the advent of flood, remains alert during the floods and takes appropriate measures to recover the damages after the cease of the flood. During floods, camps can be reached by some restricted means such as boat, elephants, marching, and swimming. Patrolling is

done mainly through boats in flood season. Moreover, many camps in the park are underwater during high floods that force the inmate to vacate their posts. The flood stands as an obstacle against maintaining well communication between the various camps and with the Range Headquarters.

3.2 Beneficial Effects of Floods on the Park

Though the flood makes a heavy loss to the park annually in varied forms, it is considered as a necessary evil by the park management. However, the flood repays the park through maintaining its unique ecosystem in the ways of refilling the wetlands, refreshing grasslands and removing invasive species, on annual basis. In the absence of the floods, it would entail harder job and hence, a huge cost for the park management to accomplish such essential tasks. In this sense, it can be termed as a boon for the park. The flood is highly essential for the park for nourishing and reviving its ecosystem in several ways as follows:

¹⁶ Manoj Kumar Misra. *Improving protection and building capacity of staff at Kaziranga National Park*, UNESCO-IUCN-WII, Delhi; 2005.

3.2.1 Nourish and refresh the water bodies

On an annual basis, the floods nurturing and refreshing the water bodies/wetlands of the park¹⁷ naturally maintain such key habitats for most of the endangered mammals such as Rhinoceros, Swamp deer, Asiatic wild buffalo and elephants. These are the important breeding ground and nurseries for numerous fishes. These also act as the roosting and nesting ground for migratory and indigenous water birds. In the absence of floods at least for two consecutive years, these water bodies would not be suitable for drinking for thousands of species in the park¹⁸.

3.2.2 Maintain grasslands

The floods with its sediments fertilize the soil of the park and help to grow a variety of flora in its landscape, which are the vital fodders for the herbivours of the park. It maintains the grasslands of the park refreshing and nourishing these annually.

3.2.3 Provide a natural drainage system

For the park, the floods act as a natural drainage system that help in growing new vegetation in place of the decayed and uprooted ones. Hence, the flood water supplies the necessary energy to survive the ecosystem of the park. If the floods do not emerge annually in the park, in the absence of sufficient water, the ecosystem of the park would largely be a solid land mass-based instead of being a floodplain.

3.2.4 Wash out the invasive weeds

The flood water washing out the invasive weeds such as water hyacinth, Mimosa invisa and wild rose clean up the water bodies and grasslands of the park almost on perennial basis. In the absence of the floods, the manual methods of physical uprooting for cleaning out these invasive weeds is not only costly and time consuming, also a harder job. The increased growth of water hyacinth usually seizes the water bodies while Mimosa and wild rose invade the grasslands and forest covers of the park. The tremendous growth

of Mimosa and wild rose highly disturb the movement of the animals, even for large mammals such as elephants, buffalos and rhinoceros and restrict them within a narrow area of the park. Moreover, these weeds not only damage the swamplands, habitats and grazing areas of animals and birds; also reduce the diversity of other plant species.

3.3 Strategies Adopted by the Park Authority to Manage the Flood Seasons

The park authority has adopted a number of measures effective to manage the flood seasons for minimizing its adverse effects on the park.

- i. With extending the patrolling hours of the existing frontline staff and with appointing casually additional local people at the fringe areas of the park, the management has increased the patrolling duty in the park during the flood seasons.
- ii. The camps are organized well to fight against the exaggerated poaching and to rescue the vulnerable animals during the floods. In addition to maintaining the existing floating camps well, some new speed boats have been acquired.
- iii. To prevent the outbreak of diseases, the park authority in collaboration with the civil administration, NGOs, and local communities organizes vaccination campaign at the peripheral villages almost on annual basis prior to the floods.
- iv. The park management has kept intense surveillance on the NH-37. Patrolling duty around the clock has been made on the animal corridors along the NH-37.
- v. It has controlled the speed of vehicles on NH-37 by adopting several measures such as rumble strips/ speed breakers, traffic light and speed monitoring device. In addition to these, time cards have been issued to regulate the speed of the vehicles.
- vi. The park management has proposed for construction of flyover at strategic places on NH-37 crossing the southern boundary of the park with a length of around 35 km.
- vii. With newly constructed 33highlands in 2017, till now, the park has maintained as

¹⁷ At present, KNP has 92 perennial water bodies and more than 250 seasonal water bodies that constitute around 7 percent of the total area of the park.

¹⁸ Rabin Sharma. *Wildlife and people work together during Assam's annual tryst with floods, Guwahati, Mongabay*; 2019.

many as 144 highlands at different locations in the park for sheltering the wild animals.

- viii. The park management has arranged for flood and disaster management control room in each range with the essential infrastructure such as rescue vehicles, early warning systems (floods/ wind/ epidemics etc.), quarantine, relief and rehabilitation, and first aid.

4. CONCLUSION AND POLICY PRESCRIPTION

Causing different types of hardship on the park such as animal casualty, habitat degradation, land erosion and damage of infrastructure; the perennial flood stands as one of the major challenges to the biodiversity conservation and sustainability of the park. For minimizing the adversities of the floods on the park, the park management remains alert and adopts a number of measures to manage the flood seasons. Recently, with the construction of 33 new artificial highlands and several effective measures on NH-37, the animal casualty during the floods is found to be in a declining trend. Though the addition of new highland policy of the park is effective in reducing animal casualty during the floods, the construction of more highlands inside the park may disturb the natural ecosystem of the park. However, the blockage of the animal corridors along the NH-37 by the increased human activities necessitates the construction of highlands in the park. In contrast, the flood benefits the park at a large by naturally maintaining its floodplain ecosystem in the ways of refilling the water bodies, refreshing and nourishing grasslands and washing out invasive flora, on annual basis. In the absence of floods, it would be a highly expensive, time consuming and harder job for the park to perform these essential tasks. Hence, the floods may more appropriately be described as a necessary evil for the park. For maintaining the unique ecosystem of the park, flood is highly essential phenomenon and welcome to the park.

Under the above circumstances, for minimizing the adversities of the floods on the park, the following have been suggested for policy prescription:

- i. For reducing animal casualty during floods, the animal corridors along the NH-37 need to be secured for ensuring a safe passage

to the Karbi Hills. For it, the flyover with reasonable height and length may be constructed over the major animal corridors along the NH-37. Any kind of human activity in and around the animal corridors should be banned through the enactment of the appropriate laws by the government.

- ii. Considering the increasing population of fauna and natural ecosystem of the park, more highlands need to be constructed in the fringe and addition areas of the park instead of the core areas of the park.
- iii. The government needs to enhance the resources, basic amenities, equipments and manpower of the park for enabling the park to manage the flood seasons properly.
- iv. The civil administration, NGOs and local people should cooperate with the park management in relief and rehabilitation of the flood affected animals. Wildlife lovers and tourists may contribute to the flood relief fund of the park.
- v. The park authority should utilize the flood relief fund properly in various essential measures required to mitigate the adversities of the floods.
- vi. Various measures adopted on NH-37 during the floods need to be implemented strictly. The clock round patrolling duty mainly in the animal corridors and more speed breakers/ rumble strips may be more effective measures for lessening traffic jam and the speed of the vehicles during the floods.
- vii. The government should adopt appropriate scientific measures to reduce the erosion of the river bank on the northern boundary of the park.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Peer-review history:

*The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/87014>*