RESEARCH ARTICLE

LIVING ON THE EDGE: HUMAN-WILDLIFE CONFLICT AND AGRICULTURE DESTRUCTION IN KERALA: A CASE STUDY ON PANAMARAM PANCHAYATH, WAYANAD DISTRICT

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Manuscript Info	*Abstract*
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	Wayanad district in Kerala is basically an agrarian economy, but recently farmers in Wayanad facing many problems including crop destruction by wild animal attacks. Thisimpaires agriculture production, lowers income, has negative effects on education, health, and development in the long run.Human-wildlife strife may be a contentious issue within Kerala Western Ghats, as well as in other regions of India. This paper attempts to analyse the crop destruction due to human-wildlife conflict in agriculture sector and also to assess human casualties, various techniques adopted by farmers and government institutions to prevent wild animal attacks in PanamaramPanchayath of Wayanad district.

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Introduction:-

As inhabitants of the same planet, human and creatures have continuously coexisted. Expanded human populace combined with quick urbanization and industrialization has been applying impressive weights on the common environment. Environment annihilation has gone to a degree presently where both man and creatures are progressively competing for constrained space and assets. This competition for common assets has pitched people and natural life as foes in a struggle for survival. "Human-wildlife conflict (HWC) happens when desires and behavior of natural life affect adversely on the objectives of humans or when the objectives of human adversely affect the wants of natural life. These conflicts may result when natural life harm crops, harm or slaughter household creatures or slaughter people." (IUCN World Preservation Union, 2004).

India, being the most populous country, seventh largest country globally and the second largest in Asia, characterized by ten distinct biogeographic zones that feature diverse landscapes and abundant natural resources. The nation boasts a remarkable biodiversity, with approximately 45,000 plant species, 86,874 animal species, 390 mammal species, 1,300 bird species, 456 reptile species, 311 amphibian species, and 2,546 fish species. Each biogeographic zone is confronted with the challenge of human-wildlife conflict (HWC) to varying extents, involving a range of species. Key species contributing to HWC include the elephant, gaur, tiger, porcupine, snow leopard, wild ass, Himalayan bear, various monkeys, nilgai, blackbuck, wild boar, leopard, sloth bear and crocodile. In the Trans-Himalayan and Himalayan regions, HWC primarily arises from interactions with snow leopards, Himalayan bears, and monkeys. In the desert zones of Thar and Kutch, issues related to wild ass and nilgai are particularly pronounced. The number of species contributing to HWC is relatively consistent across the semi-arid regions. In Western Ghats, Deccan Peninsula, and Gangetic plain areas, species such as wild boar, elephants, nilgai, monkeys,

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and various antelopes significantly impact agricultural landscapes, while predators like tigers and leopards are responsible for livestock predation and human fatalities.

HWC manifests in several ways:
1. Human fatalities: Species that attack humans in defense or for food, leading to fatalities, include tigers, leopards, lions, sloth bears, and elephants.
2. Livestock predation: Species that prey on livestock include leopards, lions, tigers, and wild dogs.
3. Accidental injuries: Species that inadvertently attack humans or livestock in self-defense include gaur, nilgai, elephants, leopards, tigers, wild boars, and crocodiles.
4. Agricultural Crop Damage: The absence of preferred food sources in their natural environments forces certain animal species to rely on agricultural crops, resulting in significant destruction. Notable culprits include wild boars, nilgai, elephants, rhesus macaques, and blackbucks.
5. Property Damage: Various species contribute to the destruction of residential areas and other structures, including elephants, rhesus macaques, and bonnet macaques.

Broad causes of Human Wild Animal Conflict: Five basic categories can be used to broadly classify the "causes" of conflict between humans and wildlife.
1. A decline in the quantity and quality of habitat that is now accessible as a result of encroachments, deforestation, denotation of Protected Areas (PA), increased settlement and cultivation, etc.
2. A particular species' easier access to and/or greater abundance of palatable food and other resources outside of a protected area (PA) compared to inside, even in situations where the PA is both sizable and rich in nutrition.
3. The social structure and behaviour of a particular species, which may lead to individuals or groups being compelled to diverge from the main population and establish themselves on PA edges near (or inside) populated areas.
4. Poverty and other restrictions that push marginalized people into protected areas and encourage them to take use of the environment (by hunting, grazing, gathering wood, leaves, fruits, etc.) put them in direct and indirect conflict with wild animals.
5. Rapid increases in the number of people or wild animals living in an area, which heightens the frequency of interactions between the two groups and intensifies other elements that contribute to conflict. (When a wild animal population exceeds a PA's carrying capacity, individuals and groups may "spill over" into agricultural areas and human settlements.)

As India's population continues to expand, the country confronts a growing challenge in managing the increasing intersection between human settlements and wildlife habitats. A recent investigation published in Science Advances indicates that by the year 2070, this intersection will become more pronounced across over half of the Earth's terrestrial landscape, primarily driven by human population growth rather than shifts in wildlife distributions attributable to climate change. In India, characterized by its dense human and wildlife populations, this trend poses a considerable conservation challenge that necessitates strategic planning and focused interventions. India boasts a remarkable array of wildlife, including emblematic species such as tigers, elephants, and leopards. However, it is also one of the most densely populated nations globally, with more than 1.4 billion individuals sharing environments that are also essential for wildlife. The research titled "Global expansion of human-wildlife overlap in the 21st century," conducted by the University of Michigan, predicts that India, alongside other heavily populated areas like China, will witness some of the most significant levels of human-wildlife overlap. This increased proximity raises the likelihood of conflict, as wildlife may damage agricultural crops, threaten livestock, or pose direct risks to human safety. In turn, human activities such as deforestation, urban development, and agricultural expansion will further intrude upon natural habitats, forcing wildlife into increasingly smaller and fragmented territories.

Table 1:- Human Death/ Casualties due to Tiger and Elephant Attack.

S. No.	State	2018-19		2019-20		2020-21		2021-22		2022-23	
		EA	TA	EA	TA	EA	TA	EA	TA	EA	TA
1	AndhraPradesh	7	0	4	0	6	0	N*	0	5	N*
2	ArunachalPradesh	0	0	0	0	0	0	2	0	0	N*
3	Assam	84	0	75	0	91	0	63	0	80	N*
4	Bihar	N*	0	N*	1	N*	4	N*	9	N*	N*
5	Chhattisgarh	61	0	77	0	42	0	64	0	69	3

| 6 | Jharkhand | 87 | 0 | 84 | 0 | 74 | 0 | 133 | 0 | 96 | N* |
7	Karnataka	12	4	30	0	26	1	27	1	29	3
8	Kerala	27	0	12	2	20	0	25	0	22	N*
9	Madhya Pradesh	N*	1	N*	11	N*	2	N*	3	N*	4
10	Maharashtra	1	26	1	25	N*	32	0	82	2	35
11	Meghalaya	3	N*	4	N*	6	N*	3	N*	3	N*
12	Mizoram	N*	0	N*	0	N*	0	N*	0	N*	N*
13	Nagaland	1	N*	0	N*	0	N*	0	N*	1	N*
14	Odisha	72	0	117	0	93	0	112	0	148	N*
15	Rajastan	N*	5	N*	0	N*	0	N*	0	N*	N*
16	TamilNadu	47	0	58	1	57	3	37	0	43	1
17	Telungana	N*	0	N*	2	N*	0	N*	0	N*	N*
18	Tripura	N*	N*	2	N*	1	N*	2	N*	2	N*
19	UttarPradesh	0	8	6	4	1	11	0	11	4	N*
20	Uttarakhand	3	2	N*	0	N*	1	N*	3	4	N*
21	WestBengal	52	3	116	5	47	5	77	1	97	N*
Total		457	49	586	51	464	59	545	110	605	46

N*- InformationnotreceivedfromState

EA-Elephant Attack, TA- Tiger Attack

Source: Govt. of India, Ministry of Environment. Forest and Climate Change, 2024

The overall totals (table-1) provided at the bottom of each year, indicating fluctuations in incidents across the years, with an increase from 457 (EA) in 2018-19 to 605 in 2022-23, while the TA category shows inconsistency. Not all animals and birds identified in India contribute to human-wildlife conflict (HWC). Among the 103 species implicated in agricultural damage, various species affect crops at different growth stages. Of the 1,364 bird species, 63 have been recognized as predatory, inflicting harm on a range of agricultural and horticultural crops, particularly during their most vulnerable phases. Among the six antelope species documented in India, three—nilgai, blackbuck, and four-horned antelope—are noted for their role in crop damage.

Fig. 1:- Human Death/ Casualties due to Elephant Attack.
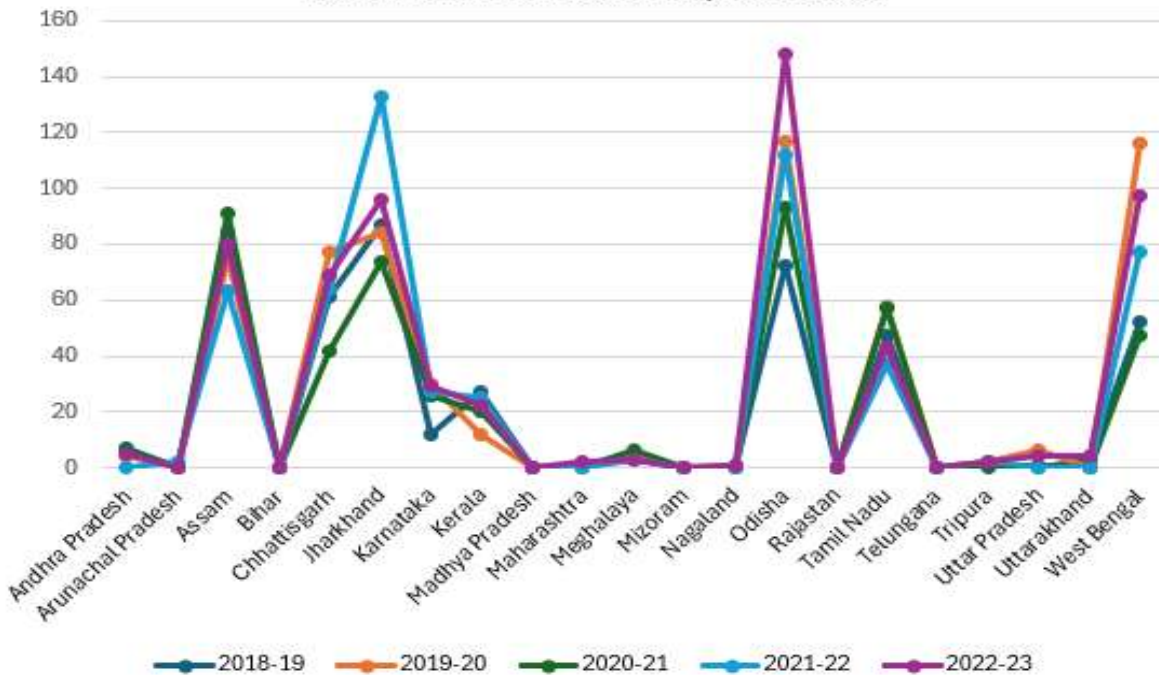
Source: Author's creation, 2024

Elephants are significant contributors to crop destruction, property damage, and human injuries, particularly in forest fringes and during migration through corridors. The wild boar stands out as the most problematic species, causing considerable crop damage across diverse agro-climatic regions of the country. Incidents of wild animal attacks in India from 2018 to 2023 across various states categorizes into "Elephant Attacks" (EA) and "Tiger Attacks" (TA). Elephant Attacks (EA) shows variability across the years, starting with 457 incidents in 2018-19 and increasing to 605 in 2022-23(fig-1). Tiger Attacks (TA) are less frequent and show inconsistent numbers, with totals fluctuating yearly (fig-2). States like Assam, Odisha, Jharkhand, and Chhattisgarh report higher elephant attacks, while tiger attacks remain notably fewer across states. Some states, such as Bihar and Mizoram, have sparse or missing data on these incidents.

Fig. 2:- Human Death/ Casualties due to Tiger Attack.
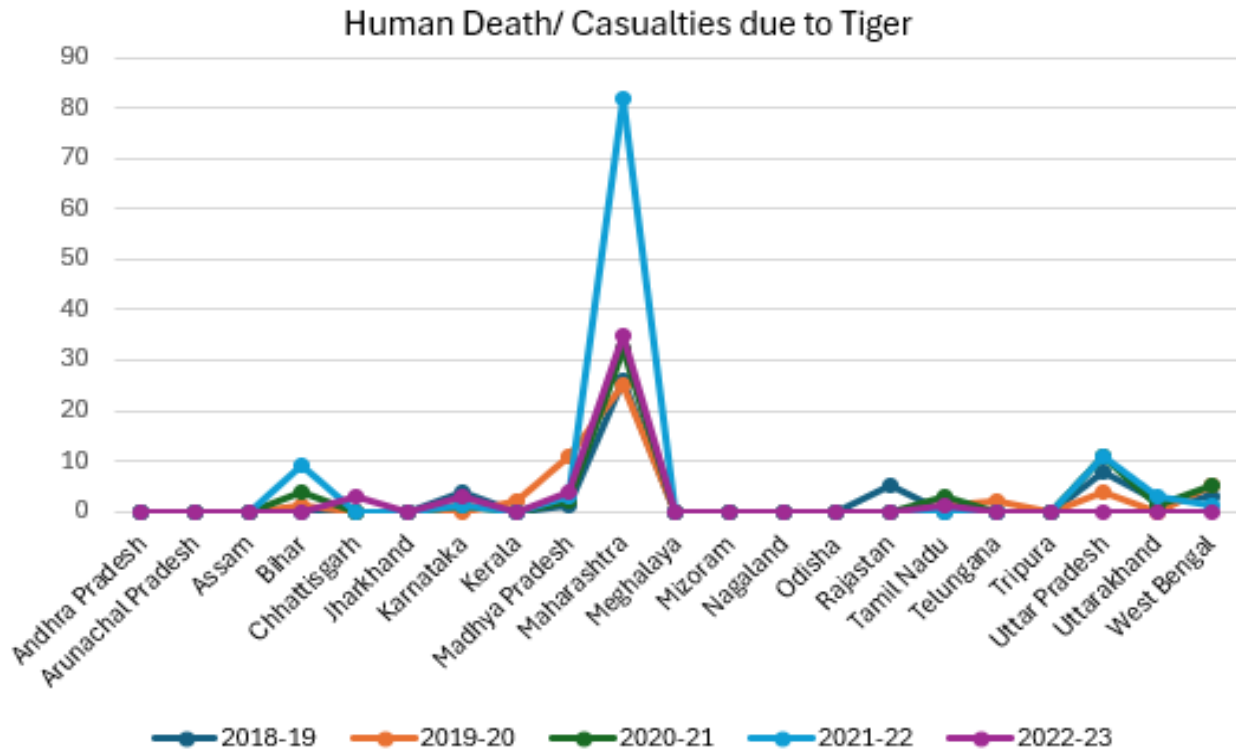
Source: Author's creation, 2024

Research conducted by the All-India Network Project on Vertebrate Pest Management over the past decade indicates that rodent species account for approximately 15per cent of agricultural damage, while birds contribute around 9per cent. Recent findings show that wild boar damage to crops ranges from 15per cent to 40per cent, nilgai from 10per cent to 30per cent, elephants from 20per cent to 50per cent, rhesus macaques from 10per cent to 30per cent, blackbuck from 5per cent to 15per cent, and gaur from 5per cent to 10per cent. The severity of damage is influenced by factors such as population density, cropping patterns, the extent of cultivated area, seasonal variations, and the growth stage of the crops.

Review of Literature:-
Latest reviews on HWC mainly focused on crop damage caused by wild animals in agriculture area, particularly those people living near the wild animal habitat area and protected forests. Elephants, wild boars, and primates (e.g., macaques) are consistently reported as major crop raiders across multiple studies (Veeramani& Jayson, 1995; Jayson, 1998; Easa&Sankar, 2001; Gubbi, 2012).Other significant raiders include porcupines, deer species, and various birds (Srivastava, 2000; Govind& Jayson, 2018). Major crops affected are Paddy (rice), sugarcane, and various grains (Easa&Sankar, 2001; Gubbi, 2012). Other vulnerable crops frequently targeted are tapioca, coconut, coffee, rubber, and various fruits and vegetables (Veeramani& Jayson, 1995; Jayson, 1998). Some studies highlighted the patterns and factors influencing crop riding by animals. Proximity to forest edges and water sources

increases the likelihood of crop raiding (Mutanga&Adjorlolo, 2008; Ankur et al., 2017). Seasonal variations affect raiding patterns, with some studies noting increased activity during dry seasons or specific crop growth stages (Aparna, 2015; Mamo et al., 2021). Major economic impact of HWC is crop damage , that can lead to significant economic losses for farmers, with some studies reporting up to 20per cent average crop loss per year (Aparna, 2015). Compensation schemes given to farmers were often cover only a fraction of the actual losses incurred by farmers (Madhusudan, 2003; Rohini et al., 2016). Mitigation startegies adopted or various deterrent methods have been studied, including electric fencing, community-based approaches, and alternative cropping strategies (Osborn & Parker, 2002; Subedi et al., 2020). The effectiveness of guarding crops shows mixed results across studies (Ankur et al., 2017). There's a need for more comprehensive and efficient compensation schemes (Khare, 2021; Sumitha&Shaharban, 2022). Collaborative efforts between forest departments, local communities, and farmers are emphasized for effective conflict management (Rathi et al., 2020; Meena et al., 2023). This review highlights the complex nature of human-wildlife conflict in agricultural areas, emphasizing the need for multifaceted approaches to mitigate crop damage while supporting conservation efforts.

Methodology:-
The study was mainly conducted in PanamaramGramapanchayath of Mananthavadythaluk in Wayanad district. Panamarampanchayath has a population of 12683, out of that 6464 were females and 6219 were males, according to the 2011 population census. The number of households surveyed includes different types of farmers affected by crop raiding by wild animals, concentrates on the farming households in the study area. The main sources of primary data, details of farmers were collected from the PanamaramGramapanchayath. Out of the many farmers in the panchayath, 60 farmers were selected using purposive sampling method. For the investigation, a structured questionnaire was created and employed. The secondary data was gathered from multiple sources, including Economic Review, departmental (both central and state government) and online publications, and other scholarly periodicals. Collected data were classified and tabulated using tables and graphs. Mean, percentages, regression analysis etc. were used for data analysis.

Results and Discussion:-
The agriculture sector of Wayanad district is now in distress because of sharp decline in production as well as productivity due to climate change, crop disease, untimely rain, shortage of labor, high wage, etc.. Apart from this the agriculture sector faces the problem of crop destruction due to wild animal attacks. Crop raids and attack by animals has gone up considerably in Wayanad. Animal damage to cash crops and food affects the livelihood of rural farmers. This ultimately reduces income of the farmers and their livelihood options. Farmers are trying to implement various techniques to prevent wild animals' attack. Protection of crops from wild animal raids can considerably enhance farmer's income and sustainable livelihood options.

The HWC presents a complex challenge, and the Department is actively pursuing various strategies to address this issue effectively. Elephants are primarily responsible for the destruction of lives and crops among communities residing in the peripheral regions of forests. Additionally, other wildlife species such as tigers, leopards, wild boars, and peacocks contribute to these conflicts. Several factors have been identified as contributing to the current situation, including the escalating human population, habitat destruction and fragmentation, alterations in agricultural practices, climate change, and an increase in wildlife populations. To significantly mitigate the challenges associated with the human-wildlife interface, a comprehensive strategy encompassing both long-term and short-term measures for prevention and mitigation must be implemented. The incidence of human-animal conflict has surged in recent years, resulting in a rise in compensation claims. Over the past decade, Kerala has reported 98 human fatalities, with 69 percent attributed to snake bites.

Table 2:- Detail of HWC reported in Kerala and Compensation paid in 2018-19 & 2022-23.

Causes	Human Death		Human Injured		Cattle Death		Crop Damage and Property Loss	
	2018-19	2022-23	2018-19	2022-23	2018-19	2022-23	2018-19	2022-23
Snake bite (in nos)	123	52	541	767	11	27	0	26
Elephant attack (in nos)	17	27	46	34	29	1	4063	2919
Wild Boar attack (in nos)	5	8	169	146	24	3	1230	1898

Wild Gaur attack (in nos)	0	0	1	2	3	0	52	58
Tiger Attack (in nos)	0	1	0	0	125	141	0	23
Leopard Attack (in nos)	0	0	0	0	104	164	0	7
Others (in nos)	1	0	8	39	52	64	1286	1610
Total Incidents (in nos)	146	88	765	988	348	400	6631	6541
Compensation paid (in lakh ₹)	242.7	270.5	258.4	259.3	88.4	53.8	525.6	461.3

Source: Forest and Wildlife Department, GoK, 2019, 2022

The data provides details of human-wild animal conflicts in Kerala for the years 2018-19 and 2022-23, along with the compensation paid. Snake bites caused the most fatalities and human death, with a decrease from 123 in 2018-19 to 52 in 2022-23. Deaths from elephant attacks rose from 17 to 27. Human Injuries/Incidents of injuries rose, especially from snake bites, from 541 to 767. Cattle Deaths increased in cases involving tigers and leopards, while elephant-related cattle deaths dropped. Crop Damage/Property Losses are mostly due to elephant and wild boar attacks, with a slight decrease from 6631 incidents to 6541 (table-2).

Total compensation slightly increased in some categories, with payments for human injuries and crop/property loss remaining high. For instance, compensation for crop damage and property loss was ₹525.6 lakh in 2018-19 and ₹461.3 lakh in 2022-23. This data reflects the ongoing challenges with human-wildlife conflicts, particularly involving elephants and snakes, and the financial burden on the state for compensations.

Data on human-wildlife conflicts in Kerala, particularly focusing on damage to crops by wild animals and the compensation paid for these losses shows that elephants, bonnet macaques, wild pigs, sambar deer, chital, and gaur are the main animals causing damage. Crops most frequently affected include coconut, areca nut, plantain, coffee, paddy, and tubers. Elephants and wild pigs cause the highest damage across multiple crops.

Table 3:- Conflict Incidents on Crops/Cultivation (2013-14 to 2018-19).

Crops	Coconut	Areca nut	Plantain	Coffee	Paddy	Tubers
Elephant	4991	4441	8926	3109	1739	1103
Bonnet macaque	2139	1819	2973	1701	65	885
Wild Pig	886	608	3074	432	1050	802
Sambar	0	0	83	0	0	0
Chital	0	0	50	0	41	0
Gaur	0	0	23	0	0	0

Source: Forest and Wildlife Department, GoK, 2019

Frequency of Damage from (2013-14 to 2018-19) shows that Plantain was notably impacted, with 8,926 cases linked to elephants and 3,074 linked to wild pigs. Coconut and areca nut also faced significant damage, primarily from elephants and macaques. Compensation data for the years 2018-19 and 2022-23 highlights government efforts to support farmers impacted by these wildlife conflicts (table.3). The data reflects a need for strategic interventions to manage human-wildlife interactions, particularly involving elephants and wild pigs due to their high impact on essential crops in Kerala.

Livestock Death and Injury by Wildlife in Kerala (2013-14 to 2018-19) shows that major Species Involved are Elephants, leopards, tigers, snakes, wild dogs, and wild pigs caused livestock losses. 814 cases of livestock death/injury were recorded. Tigers caused the most harm with 420 cases, followed by leopards with 173 cases (table.4).

Table 4:- Death/Injury of Livestock caused by Wild Animal (2013-14 to 2018-19).

Species	Elephant	Leopard	Tiger	Snake	Wild Dog	Wild Pig	Total
Cattle	20	93	250	58	8	18	447
Buffalo	0	2	47	5	2	1	57
Goat	6	78	123	35	54	14	310
Total	26	173	420	98	64	33	814

Source: Forest and Wildlife Department, GoK, 2019

Kerala has set a model as the first state in India to develop and implement an extensive array of sanctioned protocols for the rescue and liberation of snakes from areas inhabited by humans. In the fiscal year 2022-23, training was provided to approximately 1,400 individuals in snake rescue and release techniques. Of these, around 850 trainees received certificates, officially recognizing them as certified snake rescuers. The entire rescue operation has been streamlined through a dedicated mobile application called Sarpa. This initiative aims to achieve several objectives, including the protection of human lives during snake rescue operations and the effective conservation of reptiles that pose threats in areas dominated by human activity. Wild animals frequently sustain injuries due to various factors, such as road accidents, entrapment in abandoned wells or ditches, snares set by poachers, or local efforts to deter wildlife from agricultural lands. It is imperative to rescue these injured animals and provide them with appropriate medical care.

The Forest Department, with financial support from KIIFBI, is executing a substantial project valued at 110 crores, titled "Fencing along identified areas of forest boundary to mitigate human-wildlife conflict." This project is being carried out in two phases and encompasses strategies to prevent wild animals from encroaching on human habitats. These strategies include the installation of solar-powered fences, construction of elephant-proof walls, implementation of crash guard steel rope fencing, rail fencing, and the voluntary relocation of eligible families from forest areas to more suitable locations of their choosing.

Human-Wildlife Conflict (2009-10 to 2020-21) Payments were made for crop damage, livestock loss, and human casualties. The number of applications and total ex-gratia payments generally increased, reaching a peak of 10,095 applications in 2020-21. High compensation levels were allocated for human casualties and livestock losses, with amounts as high as 1,115 lakhs in 2018-19.

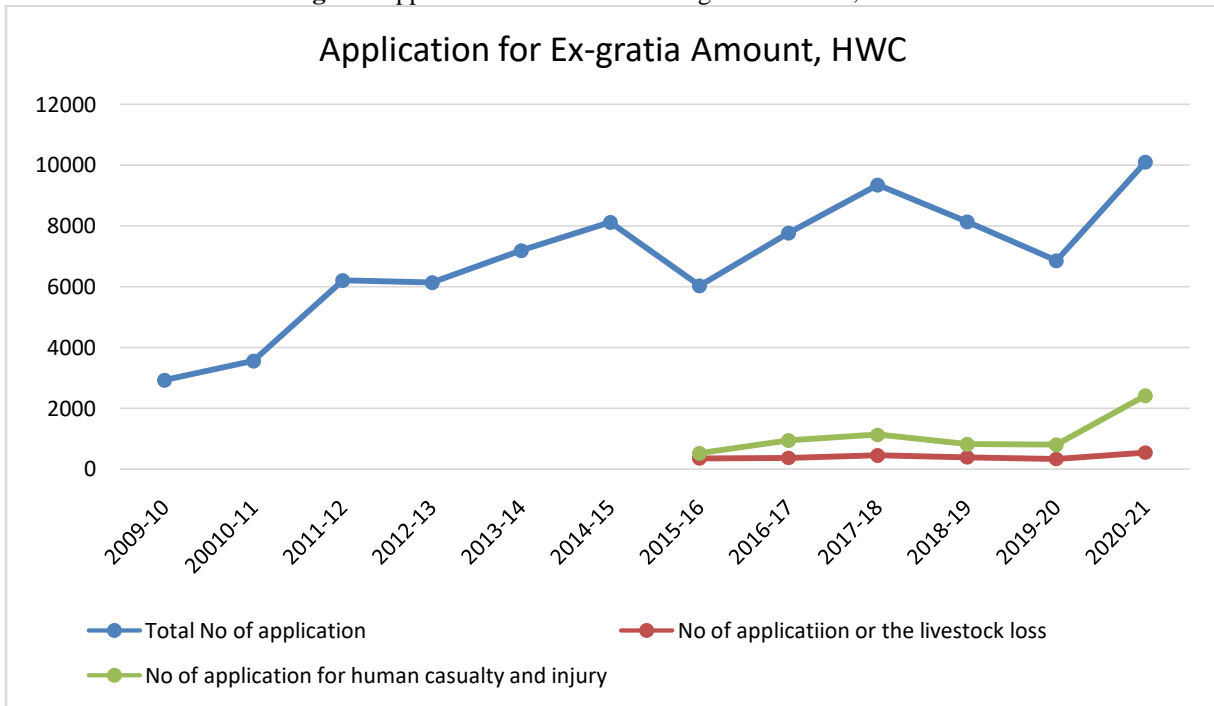**Table 5:-** Ex-gratia Payment for HWC (In Lakhs) (from 2009-10 to 2020-21).

Year	Ex-gratia amount Paid		Ex-gratia amount Paid for the livestock loss		Ex-gratia amount Paid for human casualty and injury	
	No of application	amount	No of application	amount	No of application	amount
2009-10	2922	119.3				
2010-11	3550	201.0				
2011-12	6210	454.4				
2012-13	6132	460.7				
2013-14	7188	659.1				
2014-15	8112	782.5				
2015-16	6022	681.7	355	59.76	513	238.98
2016-17	7765	963.9	361	76.39	943	467.09
2017-18	9333	1018.7	443	63.27	1121	468.96
2018-19	8125	1115.0	379	88.39	813	501.08
2019-20	6859	930.06*	330	71.74	796	437.52
2020-21	10095	842.76*	538	72.30	2416	366.00

* The figures are not final as disbursal is pending due to lack of funds
Source: Forest and Wildlife Department, GoK, 2023

Based onex-gratia payments related to livestock loss, human casualties, and injuries from 2009 to 2021, Applications increased steadily from 2010 (2,922) to 2018 (9,333).A slight decrease occurred in 2019 and 2020, with numbers dropping to 8,125 and 6,859, respectively, likely influenced by HWC factors. By 2021, applications rose again, reaching a new high of 10,095. Assuming the factors affecting the dip in 2020 are temporary, the applications may continue to increase, potentially surpassing 11,000 by 2022-2023 (fig-3).
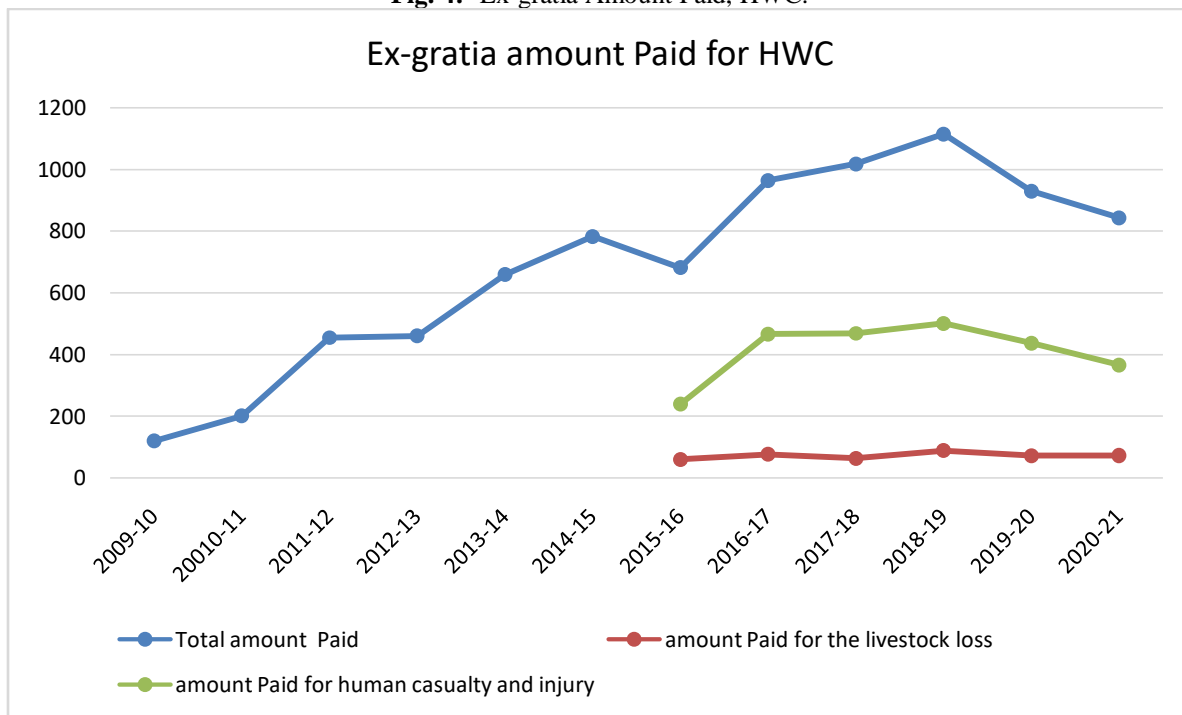
Fig. 3:- Application submitted for Ex-gratia Amount, HWC.

Application for Ex-gratia Amount, HWC

Legend:
- Total No of application
- No of applicatiion or the livestock loss
- No of application for human casualty and injury

Source: Author's creation, 2024

The total amount showed a strong upward trend, from 119.3 in 2010 to 1018.7 in 2018. Post-2018, amounts slightly fluctuated, reaching a high of 1,115 in 2019, then dropping in 2020 and 2021. If this trend stabilizes, the amount could approach or exceed 1,200 in future.

Fig. 4:- Ex-gratia Amount Paid, HWC.

Ex-gratia amount Paid for HWC

Legend:
- Total amount Paid
- amount Paid for the livestock loss
- amount Paid for human casualty and injury

Source: Author's creation, 2024

The regression summery statistics of a functional relation between the amount paid as a dependent variable and the number of applications as an independent variable shows that there exists a positive relation that the rate at which amount increases with number of application is ₹ 0.13 lakh (result is statistically significant with p value 0-00) per application.

Management of HWC in Kerala
Management strategy for mitigating HWC in Kerala is focused on preventive measures and long-term solutions. Key components include:

Preventive Barriers:
Physical barriers like electric fences and trenches are used to deter wildlife from human settlements, though maintenance and cost-effectiveness are emphasized.

Habitat Management:
Strategies will assess habitat capacity and implement scientific management, with forest areas categorized into vulnerability zones for tailored responses.

Enhanced Rapid Response Teams (RRT):
The RRTs, located in eight regions, will receive improved communication and transportation resources for faster conflict response.

Community Involvement and Early Warning Systems:
Local committees, "JanakiyaJagrathaSamithis," will help monitor wildlife movements, supported by an SMS alert system.

Public Insurance Scheme:
A government-funded insurance program will provide timely compensation for property and personal losses due to wildlife incidents.

Legislative Amendments:
Current wildlife laws will be reviewed to allow for the management of species causing significant harm, such as wild boars.

Table 6:- Major Preventive Mechanisms Adopted to Mitigate HWC in Kerala on 2018-19.

Measures	In Km	%
Solar Power Fencing	798.36	70.34
Elephant Proof trench	147.52	12.99
Elephant proof wall	22.68	1.99
Stone Pitched trench	0.26	0.02
Bio-fence	0	0
Kayyala	164.46	14.49
Others	1.80	0.16
Total	1135.08	100

Source: Forest and Wildlife Department, GoK, 2019

This approach seeks to reduce conflicts by balancing wildlife preservation with human safety, involving local communities, and ensuring adequate resources and legal adjustments for effective conflict management. In addition to conventional strategies such as crop guarding, noise deterrents, fire setting along perimeters, the establishment of basic barriers, and the utilization of traps, spikes, and firecrackers, as well as the removal of dense vegetation from field boundaries, various innovative approaches have emerged to mitigate human-wildlife conflict. These include the installation of solar fences, the creation of elephant-proof trenches and walls, the implementation of bio-fences and rail fences, and the deployment of flashlights and flares. Furthermore, an SMS alert system for farmers has been introduced to enhance communication and response. The demarcation of boundaries through the construction of permanent cairns and stone walls in ecologically sensitive regions can significantly aid in forest protection and curtailing encroachment attempts. The erection of boundary walls is recognized as an effective strategy for reducing HWC.

Preventive Measures for Human-Wildlife Conflict in Kerala (2018-19) (table-6) shows that infrastructure facilities like, measures of solar-powered fencing (798.36 km), elephant-proof trenches and walls, and other physical barriers are implemented in Kerala. Solar fencing was the most extensively implemented preventive measure, followed by traditional structures like kayyala (164.46 km).

Management of HWC under Thirteenth FYP (2017-2022)
There has been a notable rise in human-wildlife conflict over the years, resulting in adverse perceptions regarding conservation efforts. The encroachment of human settlements into wildlife habitats, particularly during times of scarce food and water resources, intensifies these conflicts, leading to significant losses in both life and property. A limited number of species, such as elephants, wild boars, monkeys, giant squirrels, and porcupines, are primarily responsible for most of these confrontations. Additionally, there has been an uptick in agricultural damage linked to peacocks. While conflicts involving tigers are comparatively rare, the species' status as a flagship species garners considerable public attention.

Table 7:- Indicative Outlay for Implementing the Programme of Management of HWC in Kerala (from 2017-2022 in Crore₹).

Programmes	2017-18	2018-19	2019-20	2020-21	2021-22	Total
Improvement of Wildlife habitats	3	3	4	5	5	20
Conflict prevention	8	10	12	15	15	60
Strengthening of Rapid Response Teams	3	3	4	5	5	20
Development of early warning system with peoples participation	2	2	3	4	4	15
Publicly funded insurance schemes	15	20	20	20	25	100
Amendment to wildlife legislation	0.4	0.6				1
Sub total	31.4	39.6	43	49	54	216

Source: Gov. of Kerala, Forestry and Wildlife Report, Govt. of Kerala, 2023

Efforts have been initiated to mitigate human-wildlife conflicts, primarily emphasizing preventive measures such as the installation of physical barriers, including electric fences, stone walls, and trenches, to deter wildlife from encroaching upon human settlements and agricultural areas. Additionally, a compensation system has been established for individuals who experience property damage or personal harm due to wildlife interactions. Nevertheless, the rising frequency of these conflicts highlights the inadequacies of the current strategies, which tend to address only the symptoms rather than the underlying causes.

Breakdown of financial investments in various programs aimed at managing human-wildlife conflicts in Kerala from 2017 to 2022, includes 1) Improvement of Wildlife Habitats: A steady increase in funding from ₹ 3 Crore (2017-18) to ₹ 5 Crore (2021-22), totaling ₹20 Crore over five years. 2) Conflict Prevention: This has the highest allocation, with a significant rise from ₹ 8 units (2017-18) to ₹15 Crore₹ (2021-22), reaching a cumulative total of ₹60 Crore₹. 3) Strengthening Rapid Response Teams: Allocation starts at ₹ 3 units and increases to ₹ 5 by the final year, totaling ₹ 20 units.4) Early Warning Systems: Investment increases modestly from ₹ 2 to 4 units, accumulating to ₹ 15 units. 5) Insurance Schemes: Funding starts at ₹ 15 units and peaks at ₹ 25 units, with a total of ₹ 100 units, indicating a major emphasis on public insurance. 6) Legislative Amendments: Minimal investment (₹ 0.4 to 0.6 units) totaling ₹ 1 unit. The overall expenditure across these programs is ₹ 216 Crore over the five-year period, showing a strategic emphasis on conflict prevention and public insurance.

During the 13th Five Year Plan, a comprehensive long-term strategy will be developed and executed, concentrating on the root causes of human-wildlife conflicts. This strategy will specifically target the following areas:

Improvement of wildlife habitats involves evaluating the carrying capacity of these environments and applying evidence-based management strategies that take into account the behavioral tendencies of different species to mitigate conflicts. This process includes classifying forest edge regions into specific vulnerability zones, informed by habitat conditions and the populations of species that are prone to conflicts. Customized management strategies will be developed and implemented for each identified vulnerability zone.While current preventive measures

predominantly focus on erecting barriers against wildlife, the overarching strategy should adopt a more holistic approach that encompasses:

1. Reducing the overlap between human and animal habitats.
2. Ensuring that human developments do not intrude upon animal habitats.
3. Considering the voluntary relocation of villages situated within forested areas.

A more accurate delineation of protected area boundaries is essential. Additionally, establishing wildlife corridors and connectivity is crucial to facilitate the unobstructed movement of animals. Enhancing the capabilities of Rapid Response Teams (RRT) is imperative. Currently, these teams operate in eight designated locations. By improving their communication and transportation resources, the RRT will be better equipped to respond swiftly and effectively to incidents of human-wildlife conflict. Encouraging community involvement and implementing an early warning system is vital. It is suggested that "JanakiyaJagrathaSamithis" be formed at the Panchayath level in regions particularly susceptible to human-animal conflicts. This initiative will include a tracking system for problematic individuals and species, along with the establishment of an SMS alert system. The introduction of a publicly funded insurance scheme is necessary. The Forest Department incurs significant costs each year in compensating for damages caused by wildlife. To ensure prompt compensation for those affected, an assessment will be conducted to evaluate the feasibility of a publicly funded insurance scheme. This scheme will aim to provide timely financial support for losses related to life and property, covering every individual or household in areas at risk of wildlife damage. Revisions to wildlife legislation are urgently required. A comprehensive review of existing wildlife laws is necessary to implement appropriate amendments that allow for the culling of problematic species, such as wild boars, which cause extensive damage. The current legislation is overly rigid, limiting the potential for science-based management interventions.

Human Wild Life Conflict in PanamaramPanchayath, Wayanad

Data collected from PanamaramPanchayath gives detailed insights into the human-wildlife conflict, including agricultural practices, crop damage, seasonality of wildlife raids, economic losses, and the effectiveness of various prevention methods. The agricultural practices of the surveyed respondents reveal a diverse range of crop cultivation, including paddy, coconut, banana, coffee, arecanut, ginger, turmeric, and rubber. Among these, paddy emerges as the predominant crop, cultivated by 20 farmers, followed closely by coffee and banana. Out of the total 60 farmers surveyed, a significant number engage in these agricultural activities.

Table 8:- Agriculture Practices and Land Use in Panamaram.

	Nature of agriculture	Number of Farmers	%
Nature of agriculture	Full time	50	83
	Part time	10	17
	Total	60	100
Type of land	Owned	50	83
	Leased in	10	17
Area of land (In Cents)	0-10	1	2
	10-50	14	23
	50-100	30	50
	100-200	13	22
use of total area for cultivation	Yes	7	11.7
	No	53	88.3
Reasons for non-use of total area for cultivation	Wild animals	20	38
	High cost	14	26
	Low price of crops	12	23
	Other reason	7	13

Source : Primary Survey, 2024

Agriculture Practices and Land Use: In Wayanad'sPanamaram region, wild animal encroachment significantly impacts farming and has even led to house displacement among residents. Frequent incursions by wildlife into agricultural fields have not only caused extensive crop damage but also left many farmers unable to utilize their entire land holdings, as they fear continued losses and destruction. Key crops such as paddy, banana, and coffee are

particularly vulnerable, leading farmers to abandon portions of their land or, in extreme cases, reconsider their entire approach to cultivation.

Most farmers (83per cent) engage in full-time agriculture, with paddy, banana, and coffee being the predominant crops. While 83per cent own their land, only 11.7per cent utilize the entire area for cultivation, with wildlife being a primary reason for leaving land fallow. This ongoing struggle with wildlife has even pushed some families to relocate their homes for safety, as physical barriers like fences and trenches often prove insufficient to keep animals at bay. Consequently, the community is experiencing a dual loss: reduced agricultural productivity and forced displacement, disrupting both livelihoods and longstanding connections to their land.

Table 9:- Crop Damage and Cost Analysis in Panamaram.

Types of Crops	Area/cent	Average Cost /farmer	Average Revenue/farmer	Cases of crop damage by wild animal	%
Paddy	1180	353000	371000	20	29.41
Coconut	220	36000	30500	6	8.82
Banana	490	39000	38000	12	17.65
Coffee	550	320500	315000	10	14.70
Arecanut	280	28350	27500	8	11.76
Ginger	184	37500	36300	9	13.23
Turmeric	170	13500	15100	3	4.41
Rubber	100	10000	12000	-	

Source: Primary Survey, 2024

Paddy experiences the highest crop damage, accounting for 29.41per cent of wildlife-related cases, followed by banana (17.65per cent) and coffee (14.70per cent). The total revenue from all crops (₹845,400) is slightly higher than the costs (₹837,850), though wildlife damage impacts profitability.

Table 10:- Seasonality and Frequency of Wildlife Raids:

	Season of raiding behaviour	Frequency	%
Season of raiding behaviour	Summer	12	20
	Rainy	47	78.3
	Winter	1	1.7
Damage intensity	Fruits	5	8.3
	Full crops/field	55	91.7
	Damage of neighbouring fields	60	100
Frequency of raiding	Daily	3	5
	Weekly	4	6.7
	Occasionally	53	88.3

Source: Primary Survey, 2024

Wildlife incursions peak during the rainy season (78.3per cent), primarily resulting in extensive crop or field destruction (91.7per cent). Raids are mostly occasional (88.3per cent).

Table 11:- Agriculture Loss in Rupees.

Approximate loss	Frequency	%
Less than 5,000	0	0
5,000-10,000	2	3.33
10,000-50,000	21	35
50,000-1,00,000	27	45
Above 1,00,000	10	16.66

Source: Primary Survey, 2024

Significant economic impacts are reported in the study area, with 45per cent of farmers losing between ₹50,000 and ₹100,000 annually due to HWC, and 16.66per cent experiencing losses above ₹100,000.This loss will adversely affect their capacity to earn for their lively hood, severely impacts their familieies wellbeing, children's education etc.

The execution of preventive strategies will encompass the establishment of physical barriers. To reduce wildlife intrusions into human habitats and agricultural areas, cost-efficient and environmentally sustainable approaches will be utilized. Recognizing that numerous current infrastructures aimed at deterring these intrusions tend to degrade rapidly, a comprehensive maintenance protocol will be instituted.

Table 12:- Control Methods and Their Effectiveness:

	Methods	Frequency	%
Methods adopted by farmers for controlling crop raids	Watch and ward	35	29.41
	Fire	5	4.2
	Dogs	25	21
	Sound from metallic parts	40	33.61
	Human dummies	10	8.4
	Crackers	1	0.84
	Electric fence	3	2.52
	Others	0	0
	Total	119	100
Proper maintenance of techniques	Yes	10	16.66
	No	50	83.33
Institutions which maintained the efficiency of the techniques	Forest department	10	100
	Panchayath	0	0
	Agriculture department	0	0

Source: Primary Survey, 2024

Farmers primarily use methods like watch and ward, sound from metallic objects, and dogs to deter wildlife. Only 16.66per cent of these techniques are adequately maintained, with the forest department providing some maintenance support. Most methods are rated poorly in effectiveness, with trenches showing slightly better performance (8.33per cent rated as "excellent").

Table 13:- State of Techniques Adopted by Institutions.

Poor	Very poor	Good	Excellent	Total
		Watch and ward		
35	25	0	0	60
58.33per cent	41.66per cent	0per cent	0per cent	100per cent
		Electric fence		
17	40	3	0	60
28.33per cent	66.66per cent	5per cent	0per cent	100per cent
		Stone wall		
20	30	10	0	60
33.33per cent	50per cent	16.66per cent	0per cent	100per cent
		Trenches		
20	20	15	5	60
33.33per cent	33.33per cent	25per cent	8.33per cent	100per cent
		Cage trap		
24	36	0	0	60
40per cent	60per cent	0per cent	0per cent	100per cent

Source: Primary Survey, 2024

Preferred Future Techniques: Farmers expressed interest in adopting solar fences (43per cent) and electric fences (30per cent) for future mitigation. Overall, the data highlights the challenges faced by farmers in managing wildlife

incursions, resulting in considerable crop and financial losses. Improved preventive measures, along with better maintenance and support from institutions, are needed to mitigate these impacts effectively.

Table 14:- Techniques Want to be Adopted by Farmers in Future.

Techniques	Frequency	%
Electric fence	18	30
Solar fence	26	43
GI wire fence	6	10
Cracker line	6	10
Stone wall	4	7

Source: Primary Survey, 2024

In certain regions, individuals have indicated that they have been forced to relocate as a result of encounters with wild animals. These animals are able to breach the electric fences that delineate the boundaries of human settlements. Additionally, there are reports of individuals abandoning their agricultural activities and residences to seek refuge in alternative locations.

Compensation Details at PanamaramPanchayath: Only 20 farmers have applied for compensation. Out of this 65 per cent farmers received compensation for crop damage and 35 per cent farmers did not get the compensation. The amount of compensation received for crop damage for farmers, out of this 38.46 per cent of farmers got Rs.5000-Rs. 7500 as compensation amount. Only about 23 per cent of farmers got Rs.7500-Rs.10000 and about 8 per cent got less than Rs. 2500 as compensation. No one gets more than Rs. 10000 for meeting their loss. All of them get lesser amount compared to their huge losses.

Table 15:- Details of Compensation Amount.

Compensation amount	No. of Respondents	%
Less than 2500	1	7.69
2500-5000	4	30.76
5000-7500	5	38.46
7500-10000	3	23.07
Above 10000	0	0
Total	13	100

Source: Primary Survey, 2024

56.9 per cent farmers received information regarding compensation from forest office, 19.6 per cent from panchayath office and 9.8 per cent from agriculture department. It reveals that 86.3per cent farmers received information from government departments. 39per cent farmers reported that their source of information was friends/relatives and 9.8per cent from the media. Most of the farmer's acknwoledge forest office as the main source of their primary informationrealted to compensation.

Table 16:- Awareness and Application Status of Compensation.

Items	Awareness Level	No. of Respondents	%
Awareness about compensation	Well known	13	21.67
	Partially	38	63.33
	No	9	15
Source of information about compensation	Forest office	29	56.9
	Panchayath office	10	19.6
	Agriculture department	5	9.8
	Friends/Relatives	2	3.9
	Media	5	9.8
Status of applying for compensation	Yes	20	33.33
	No	40	66.66
Reasons for not applying for	Lack of knowledge	12	30

compensation	Time taking	15	37.5
	Multiple rounds of offices	13	32.5
Compensation received for crop damage	Yes	13	65
	No	7	35

Source: Primary Survey, 2024

About 40 farmers, (67 per cent) reported that they have not applied for compensation for crop damage due to some reasons. It was observed that time lag for compensation amount received was the most reported reason. The second most was the multiple rounds of office visits. Apart from that 30 per cent of farmers reported that lack of knowledge as major reason.

All farmers (13 beneficiaries who received compensation) responded that forest office is the only institution helping to get the compensation for farmers for the crop damage due to wild animal's attack. Because the forest office is the primary institution which deals with the matters related to HWC.

Table 17:-Beneficiaries Opinion Regarding Compensation.

Opinion		No. of Respondents	%
Opinion about compensation amount	Sufficient	0	0
	Insufficient	13	100
Opinion about compensation procedure	Simple	3	23
	Difficult	10	77
Institutions helping to get the compensation for farmers	Forest office	13	100
	Panchayath Office	0	0
	Agriculture Department	0	0

Source: Primary Survey, 2024

100 per cent farmers responded (out of 13) that the compensation amount they received for crop damage due to wild animals raiding is insufficient. 77 per cent farmers responded that the compensation procedure is difficult. The difficulty of the compensation procedure is due to time lag, official delays and multiple rounds of office visits etc.

Table 18:- Suggestions given by Sample Respondents for Mitigating HWC.

Suggestions	Frequency	%
Increase compensation amount	20	40
Provide compensation at correct time	13	26
Provide effective methods to prevent wild animals	25	50
Properly Maintain the techniques at correct time	10	20
Avoid multiple rounds of offices	12	24
Popularize compensation schemes	5	10

Source: Primary Survey, 2024

Out of the total 60 sample respondents majorly suggested providing awareness about compensation for crop damage. The greatest number of farmers wanted effective methods to prevent wild animals from crop raiding. Another suggestion is to increase the compensation amount and only 10 per cent farmers suggested for popularising the compensation schemes.This study proposes some suggestions both for farmers and government authorities.

Suggestions:-
This article outlines several comprehensive strategies aimed at alleviating HWC within the study area. Establishing various physical barriers to deter wildlife from encroaching upon human settlements and agricultural areas will be implemented with careful consideration of the landscape, natural movement patterns of animals, particularly elephants by implementing strategies to minimize HWC. Offering crop insurance, life insurance, and compensation to individuals can be effectively executed by integrating local governance bodies and forest department. Fostering community involvement in the strategies aimed at mitigating HWC by improving wildlife habitats within forested areas, grasslands and water sources, and also ensures sufficient food and water availability for animals. Promote training, raising awareness, and conducting research is also very relevant to reduce further instances of HWC.

Programs initiatives include habitat improvement, conflict prevention, rapid response teams, early warning systems, and insurance schemes. Each program area saw increased adoption over the years, with significant development in conflict prevention and insurance schemes. Tigers and elephants are major contributors to livestock loss, underscoring the need for targeted conflict mitigation. The upward trend in applications and compensation suggests escalating human-wildlife conflicts. Physical and programmatic interventions have been employed, yet the increasing demands indicate further scaling and refinement may be needed for effectiveness. Amendments to legislation and public involvement in early warning systems indicate a holistic approach, emphasizing both preventative and compensatory strategies.

Continuous oversight and proactive measures from governmental bodies are essential to deter wild animals from invading agricultural fields. It is imperative to organize awareness initiatives and forums that involve forest officials, farmers, and media representatives to enhance communication and foster a collaborative approach in addressing the issue of crop raiding by wildlife. To mitigate these incursions, the implementation of effective solar and electric fencing techniques should be prioritized. Furthermore, it is crucial for the government to provide technical assistance and financial resources for the upkeep of these fencing systems. Ensuring a consistent supply of drinking water in forest regions during the summer months can be achieved through the construction of check dams or the establishment of artificial water sources. Additionally, financial support in the form of subsidies and bank loans should be made available to farmers for the development of protective measures against wildlife. Currently, the disbursement of compensation to farmers occurs over an extended timeframe; thus, measures should be taken to expedite this process. The compensation framework should be revised, with adjustments made to reflect current market values. Moreover, crop damage caused by wildlife should be integrated into the existing crop insurance policies. It is also vital to raise public awareness regarding the compensation process and its eligibility criteria. Finally, efforts should be made to encourage greater youth involvement in agricultural and related sectors.

Conclusion:-

As agriculture and allied activities are the main livelihood of most of the people in Wayanad district, crop damage by wild animals is a severe and persistent problem in the study area. Elephants, monkeys and wild pigs are the main crop raiding animals in this area. Elephants were responsible for the most part of the damage and paddy was the most damaged crop. In certain regions, individuals have indicated that they have been forced to relocate as a result of encounters with wild animals. By providing technical support and financial assistance to farmers, government can prevent the HWC in agriculture sector. Many time compensation provided was not adequate to cover the actual casualties and loss. Compensation for crop damage due to wild animals is not a permanent solution to the problem. However, timely action for compensating the loss will help the farmers. HWC management was mainly executed by wildlife and forest department and role of the local self-government was meagre. Time lag in disbursement of compensation and power devolution issues also constraints timely disbursement of compensation. Local self-governments with active participation from the local community can play a significant role in both mitigating the issues of crop damage and timely compensation to recover the loss incurred to farmers.

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