SEASONALTY OF HUMAN WILDLIFE CONFLICTS IN WAYANAD, KERALA

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled "**SEASONALITY OF HUMAN WILDLIFE CONFLICTS IN WAYANNAD, KERALA**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associate ship, fellowship or other similar title, of any other University or Society.

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Karthik Krishnan M G

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Abbreviations and Expansions

GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
HWC	Human Wildlife Conflict
ICT	Information and Communications Technology
IMD	India Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
LRM	Linear Regression Model
NTFPs	Non-Timber Forest Products
RARS	Regional Agricultural Research Station
SIV	Simian Immunodeficiency Virus
WLS	Wayanad Wildlife Sanctuary

CHAPTER 1: INTRODUCTION

Conflicts between species is a major threat faced by the different parts of the world. Preventing these conflicts is an urgent necessity, can lead to mutual benefit and co-existence of these species. As described by World Wildlife Fund "Human wildlife conflict (HWC) is any interaction between humans and wildlife that results in negative impacts of human social, economic or cultural life, on the conservation of wildlife populations, or on the environment". This may be due to the change in resource availability or any other cause. Change in climate or seasonal can also catalyst the HWC incidents.

Climate change as per Intergovernmental Panel on Climate Change (IPCC) usage refers to a change in the state of the climate which can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. Indeed, change in climate is the biggest challenge of this century. The world, particularly the poor world is already experiencing its devastating impacts even when the temperature increase is 1.2^{o}C. Increase in the frequency and intensity of cyclones, variability in rainfall events resulting in floods and droughts, forest fires, heat waves are some among them.

India's climate is described as a *monsoon* type and found in south and Southeast Asia. Even though, there exist variations among the climatic conditions inside the country itself. Least amount of difference between the temperatures of night and day is shown by the India's coastal regions while huge difference exists in the interior regions. Climate of the country has distinct seasonal behaviours. The weather conditions change largely from one season to another. The changes in temperature are extreme in the interior regions. The coastal regions of India do not experience extreme temperatures. Winter, summer or pre-monsoon season, monsoon or rainy season and autumn or post-monsoon season are the four climatic seasons designated by India Meteorological Department (IMD) in India.

Kerala lies closer to the equator, when compared to other states of the country and is bestowed with an equitable and pleasant climate throughout the year. It is due to the proximity of the land to the sea, and the effect of Western Ghats protecting Kerala from the dry winds blowing from the north. Kerala gets an average of 3000 mm of rain per year. Kerala 's temperature usually ranges from 28 ° C to 32 ° C (82 ° C to 90 ° F) on the plains but declines to around 20 ° C (68 ° F) in the highlands. The Kerala highlands, which are areas of great tourist attraction, enjoy a cool and reviving climate all year round. Kerala 's climatic situation is varied due to its variety of geographical features. It can be divided into four seasons-Winter, Summer, Monsoon from South-West and Monsoon from North-East.

Wayanad, a district in north-eastern Kerala, stands on the southern tip of Deccan plateau and also includes part of Western Ghats. A large area of the district is covered with forest. Agriculture is the major economy of Wayanad. Many of the District lands are used for farming purposes. To earn their livelihood, over half of its population have been involved in agriculture. The district 's main agricultural crops include coffee, tea, cocoa, pepper, plantain, vanilla, rice, coconut, cardamom, tea and ginger. The district is renowned for growing rice. The district's two rice named Wayanad Jeerakasala rice and Wayanad Gandhakasala rice possesses different properties. Another type of district economy is cattle farming. The district's tourism industry is well developed and a big chunk of income comes from this industry every year and significantly helps in its economy.

As in other parts of the country and in other nations, human-wildlife conflict (HWC) is a controversial issue in the Western Ghats of Kerala. This is an all-time threatening issue for the resource rich district of Wayanad. Human-wildlife conflict occurs when requirements of wildlife overlap with the requirements of human populations, generating costs to wild animals and residents (Mardaraj and Sethy, 2015). This leads to potential injuries to both human and wildlife animals, resulting in negative attitudes toward wild animals

(Nyhus and Tilson, 2000). The highest number of injury cases due to human-wildlife conflicts were registered from Wayanad Wildlife Division compared to other divisions (Veeramani and Jayson, 1995).

Social and economic costs are also an inevitable part of human and wildlife conflicts. Livestock predation or crop raiding are substantial economic costs. In addition, 'opportunity costs' can also be related to the occurrence of wild animals, because the time needed to protect livestock reduces the amount of time that can be spent in other potentially valuable activities such as assisting with crop harvesting or attending school (Norton-Griffiths and Southey, 1995). With change in the climate, the character of extreme weather events, such as droughts and cold snaps, will also change, obliging relatively rapid changes in habitat for most animals (Root and Schneider, 2002) and this has further worsened the issue.

In 2017, Ajaisanker had studied on the HWC of the regions Meppadi, Odappallam, Bhoothanam and Thirunelli to find out the causes of the HWC, the major hotspots of conflicts of this region and to suggest the mitigatory measures. He found out that the reduced rainfall, droughts and forest fires have reduced the availability of food resources which later on turned to be the major causes of conflicts. The best mitigation measures suggested in his study was enrichment of habitats and proper fencing around the farmlands. Although large number of studies has taken place in human-wildlife conflict across the world, its relation to seasonal variation still remains unclear. In this context, this study aimed to analyse the seasonal variations in the nature and frequency of human-wildlife conflicts in the forest fringe areas of Meppadi, Odappallam, Bhoothanam and Thirunelli areas in Wayanad district, Kerala.

CHAPTER 2: REVIEW OF LITERATURE

2.1 HUMAN-WILDLIFE CONFLICT- DEFINITION

The World Conservation Union (World Park Congress, 2003) says that human-wildlife conflict happens when requirements of wildlife overlaps with the requirements of human populations, generating costs to wild animals or residents. Although in both urban and rural areas direct contact with wildlife is likely to occur, it is usually most common around and inside protected areas, where there exists scarcity of palatable food in the forest or wildlife population density is higher and animals frequently stray into near-by grazing areas or cultivated fields (Mardaraj and Sethy, 2015). This explanation includes the idea that encounters between humans and wildlife can cause both sides costs and harm and can also result in inequalities between various groups of people, i.e. human-human conflicts (Madden and McQuinn, 2014). Ocholla *et al*., (2013) pointed out that a range of direct and indirect undesirable interactions between wildlife animals and humans leads to human–wildlife conflict. This leads to potential injuries to both human and wildlife animals, resulting in negative attitudes toward wild animals (Nyhus and Tilson, 2000). A set of global changes has contributed to the boom of HWC worldwide. This can be categorized into human population growth, habitat loss of species, destruction and fragmentation, land use change, abundance and distribution of wild preys, increased interest in ecotourism, increased access to natural reserves, increased livestock populations and competitive extinction of wild herbivores, increasing population of wildlife as a result of conservation programmes, stochastic events and climatic factors (Distefano, 2005). Tufa *et al*. (2018) reported that existence of people in close proximity with the protected area, habitat disturbance, lack of buffer zone and demand for extractive forest use, were identified as the major causes for conflict between humans and large wild mammals. Human presence in protected areas has increased due to growing interest of the public in recreational activities and charismatic wildlife, such as endangered species and large carnivores, and has raised questions about the

capacity to control and handle large-scale use and access to protected areas by the public. Particularly in reserve borders, where human settlements come into contact with species that depend on widespread areas, conflict is common. As a result, in protected areas the border zones are considered as critical zones where conflict is the key cause of mortality (Distefano, 2005).

According to human disturbance index, humans have disturbed nearly three-quarters of the Earth's liveable land surface (Hannah *et al*., 1995). The landscape is made unviable for wild animals by habitat fragmentation as their needs remain unfulfilled (Naughton-Treves *et al*., 2003). Dickman (2009) added that in a wide range of circumstances the conflict between human and wildlife has been further exacerbated by the ever-increasing strain on the existing natural resources and the expansion of human power into even the remotest parts of the planet. Human-wildlife conflicts are also impacted by stochastic events such as wildfires which are difficult to forecast and prevent (Nyphus and Tilson, 2004). Baldus and Caudwell (2004) claimed that extremely important wildlife conflict drivers include attacks on people, particularly where attacks happen with alarming regularity. For example, in southern Tanzania, between August 2002 and April 2004, at least 36 people were killed, 10 injured and many dragged one or two lions out of their huts at night over an area of only 350km2 (Baldus 2004)**.**

HWC can be categorized into wildlife dimension and human dimension. Wildlife dimension results in (a) cattle-lifting, (b) crop damage, (c) human casualties, (d) zoonoses and (e) household damage. Humans are attacked by wild animals in three different ways and they are (i) Defensive attack where humans are attacked defensively by wild animals for their survival (ii) Territorial attack where territorial behaviour is shown towards same or different species and they are attacked, and (iii) Predatory attack where the animal attacks the victim as a prey (Conover, 2001). Lamarque *et al*. (2009) observed that during human-wildlife conflict, the typology includes injuries and deaths to humans, crop destruction, attacks on domestic animals, disease transmission to livestock or humans and hostile interaction with highly valuable or endangered species.

Wildlife affects people negatively (economically, physically, or psychologically) during a human-wildlife conflict (HWC), and vice versa (Draheim et al., 2015). Ogada et al. (2003) stressed that HWC has far-reaching environmental consequences.

Globally, for many endangered species, human-wildlife conflict (HWC) is fast becoming a critical threat for their survival, particularly to large and rare mammals such as the Asian lion (*Panthera leo persica*), the Sumatran tiger (*Panthera tigris sumatrae*), and also to species which are less endangered such as the Red colobus monkey (*Procolocus kirkii*), and the snow leopard (*Uncia uncia*) (Mardaraj and Sethy, 2015). Henson *et al*. (2009) highlighted that in developing countries, like Africa, the challenges due to human–wildlife conflict are more severe. Around protected areas, when human-wildlife conflicts occur, various other species are also negatively affected. More than wild species, local wildlife happens to be vulnerable to loss during human-wildlife conflicts (Fenthaw *et al*., 2017). Ogada *et al*. (2012) remarked that species which are wide-open to conflict are also more susceptible to extinction. Species conservation is highly impacted by human–wildlife conflict. It also endangers human safety and livelihood, and demands increased resources from managers (Woodroffe *et al*., 2005). Akenten et al. (2015) reported that the conflict between human and wildlife is increasingly becoming a serious threat to the survival and protection of many endangered species worldwide. The degree of damage varies depending on the locality and the species (Tufa et al. 2018).

Mardaraj and Sethy (2015) suggested that human-induced mortality of animals can be either intentional, caused by poison, capture or retaliatory shooting, or accidental, such as falling into farm wells, capture in traps set for other species or from railway accidents and road traffic. Such human-induced mortality has wider environmental impacts on biodiversity conservation and equilibrium of ecosystem and also affects the population sustainability of some of the most endangered species. In particular, damages to agricultural crops and plantations are caused by large herbivores (Datiko & Bekele, 2013). Akenten *et*

al. (2015) clarified that conflicts between elephants and humans have rocketed all through their range in recent years, and injury or death to people by elephants and crop damage are the most exposed. Problem elephants normally outspread their ranges into human settlements to feedstuff and also sometimes destroy food stores, fences and barriers or water installations, and seldom kill or injure people (Hoare, 1999). Tufa *et al*. (2018) found that in crop raiding, herbivores like primates, elephants and warthog are widely involved. This has triggered the retaliatory action by farmers (Rosen *et al*., 2012). Dickman (2009) claimed that large carnivores and other wild animals can have very significant impacts on neighboring human communities. Such impacts can range from less measurable consequences such as lower quality of life and increased cost of opportunity to strong economic hardships. Loss of life, threats to economic security, injury, reduced livelihood opportunities and food security are the damage to human interests caused by contact with such animals (Foley *et al*., 2005).

In terms of causing serious conflict, wild animal attacks on humans clearly have a very significant effect than attacks on animals or game species (Quigley, 2005). In rural landscapes adjacent to conservation areas and wilderness, where people and wildlife struggle for the same natural resources as water, pastureland and cultivation space, this is a common case and wildlife injuries are widespread. Catastrophic damages are caused to people who are without economic alternatives and depend on natural resources (Woodroffe *et al*., 2005). Conflicts between human and wildlife often disrupt human health, security and protection, and bear social and economic costs. Physical injury or death caused by large predators' attacks, exposure to zoonotic diseases and annoying encounters with small animals take high financial charges for society and individuals in the form of medical treatments to prevent and cure infections transferred from animals through human interaction (Mardaraj and Sethy, 2015). Injuries and deaths to human, even though not as common as crop damage, are worst manifestations of human-wildlife conflict. The hippopotamus was found the cause of more deaths in Africa than any other large animal for a long time. The crocodile now seems to

have overruled the hippopotamus. The major reasons for crocodile attacks becoming more common are that there are high number of large crocodiles, with a wide distribution range. Added to that, their populations can rapidly recover when provided with protection. Also, while elephants and lions can be easily detected, crocodiles are capable of living in close proximity to people without being sensed (Lamarque *et al*., 2013). Datiko and Bekele (2013) contended that because of the danger posed to humans and livestock, large carnivores have been alleged as a threat for survival of humans. Large carnivores such as lion, leopard, hyena, tiger and cheetah often threaten livestock and human health. For instance, around Chebera Churchura National Park in Ethiopia, during 2007–2011 carnivore attacks caused livestock losses of about 30 percentage. Retaliatory killing of animals was followed by this (Acha *et al*., 2017).

Social and economic costs are also an inevitable part of human and wildlife conflicts. Livestock predation or crop raiding are substantial economic costs. By crop-raiding the species lowers the surplus crops available to be supplied to the market and may even reduce the food available to nourish the family. Remarkable social costs include unwillingness by parents to send children to school. This may be due to various reasons like parent's fear that children will be injured on their way to or from school, or sometimes children need stay back at home to monitor and protect crops. Thus, the insecurity and fear that the wildlife threat produces prove substantial, and it can have severe impacts on the sense of well-being and way of life of local people (Gandiwa *et al*., 2013). Economically humans may also get affected through complete destruction or damage to infrastructure (e.g., water installation, fencing, pipes, agricultural crops, grain stores and orchards) and property, livestock depredation, spread of animal diseases. Missed school and work, loss of sleep, additional labour costs, restriction of travel, fear or loss of pets are the negative social impacts (Mardaraj and Sethy, 2015). Living close to carnivores can cause a variety of additional expenses apart from the direct impacts of depredation, as people will have to finance more profoundly in strategies such as predator control, guarding and

livestock herding (Woodroffe *et al*., 2005). These expenses can take various forms – for example, electric fencing used to shield stocks or games from predators on commercial farms in Namibia, installation costs a whopping US$ 781 / km and maintenance costs another US$ 952 / km / yr, while swing gates of lower-technology costs around US$43/km for installation and US$470/km/yr for maintenance (Schumann *et al*., 2008)**.** In addition, 'opportunity costs' can also be related to the presence of wild animals, as the time needed to protect livestock reduces the amount of time that can be spent in other potentially important tasks such as assisting with crop harvesting or attending school (Norton-Griffiths and Southey, 1995).

When crops, human properties, or lives are damaged by wildlife, this can negatively impact attitude of people towards wildlife and conservation issues (Kansky and Knight, 2014). Emerton (1999) found that local hostility to protected areas, conservation authorities and also to species targeted for protection is exacerbated by restricted or limited access to resources within reserve boundaries such as medicinal plants , water, firewood, pastures and wild meat.. Such wide human health and safety, environmental, social and economic impacts suggest that governments, scientists, local communities and wildlife managers have to recognize the problem and devise ways to solve it for human well-being and the environment (Mardaraj and Sethy, 2015).

2.2 HUMAN-WILDLIFE CONFLICT- GLOBAL SCENARIO

The abundance of cases from countries around the world shows the extent of conflict between humans and wildlife and advises that a thorough study is critical for understanding the problem and promoting conservation scenarios of potentially endangered and threatened species (Mardaraj and Sethy, 2015). Globally, human-wildlife conflict clearly occurs in an enormously wide range of circumstances, involving a large number of diverse species (Dickman, 2009). Siex and Struhsaker (1999) stated that human population growth in Africa resulted from invasion of wildlife habitats, direct conflict with local communities and the

constriction of species into marginal habitat patches. Human-wildlife conflict (HWC) is rapidly becoming a serious danger to the survival of many species which are globally endangered, particularly for rare and large mammals such as the Asian lion (*Panthera leo persica*) and the Sumatran tiger (Panthera tigris sumatrae), and also to species such as the Red colobus monkey (*Procolocus kirkii*) and the snow leopard (*Uncia uncia*) which are less endangered (Distefano, 2005). Mardaraj and Sethy (2015) found that crop damage from wild animals is the most tenacious and widespread form of human-wildlife conflict in the tropics. Such destruction has adverse effects on commercial crops (rubber, coffee, tea, and spices), staple food grains (maize, sorghum, rice, wheat, and millet), and non-grain food crops (vegetables, sugarcane, potatoes, peanuts, coconuts, bananas, cassava, and coconut). Besides the animals that feed on crops, damage often results from rooting, trampling and other types of wastage.

Taxonomically, various types of animals are involved in attacking crops. They comprise wild pigs (almost all crops), elephants (grain crops, sugarcane and fruits), black buck antelopes (sorghum, wheat and millet) and nilgai, sloth bear and black bear (maize, sugarcane and peanuts), gaur (rice and rubber), bonnet and rhesus macaques (most crops and vegetables), jackals (sugarcane, maize and fruits), porcupines (areca nuts, coconuts and vegetables) and giant fruit bats (all orchard crops and areca nuts). In South Asia there are human settlements adjacent to or within most wildlife parks. Mostly there are lengthy “edges” in the larger landscape environments that accommodate these parks, where human settlements interface with wildlife habitats. Conflicts unavoidably arise at this interface, because of the ecological, behavioural and nutritional requirements of animals. Evidences show that more than smaller animals, large-bodied animals are likely to come in conflict with humans. Wide range of species such as cats of the Panthera family or elephants may move into human settlements at the time of territorial and dispersal movements, seasonal migrations or daily foraging. For wild herbivores and carnivores both cultivated plants and livestock are striking resources respectively. Economic losses of property, crops or livelihood opportunities are

the damages that can occur to human wellbeing due to contact with such animals. Often, human lives and limbs may be lost. Nyphus and Tilson (2004) confirmed that in much of Asia, Asian elephants and tigers are a major source of conflict. In Africa, human-elephant conflict is as old as agriculture (Treves and Naughton-Treves, 1999).

From a study carried out in areas of Kenya with large wildlife, such as Trans-Mara, Taita, Kwale and Samburu. Akama (1996) pointed out that conflict was increased by the development of small-scale farming and land use fragmentation. Obviously, there have been sectioned and sold trust ranches and states as small farms were cultivated and commercial horticultural crops. Again in Sumatra the conversion of forest land into pasture and agricultural land has limited the home area of the Sumatran tiger (Panthera tigris sumatrae) to a few forest spots. In 2004, only about 500 people remained on the entire island (Nyphus and Tilson. Weladji *et al.* (2003) found that staple foods were the most affected crops and bush meat constitutes about 24 percentage of the animal protein intake from an area where wildlife is causing major damage to crops and livestock. Through illegal poaching and encroachment of farms, people try to secure their livelihoods from wild animals. In the Red Volta Valley in the mid 1990's, crop raiding by elephants was a serious issue for the farmers. Farmers' intolerance to the risk of losing crops to elephants was also reported (Adjewodah *et al*., 2005). Parker *et al*. (2007) claimed that people and elephants share a complex relationship. In the same area , people and elephants will coexist up to a certain level of human density. Elephants disappear from the landscape on exceeding this threshold. However, transformation of natural habitat to agricultural land affects the elephants more than the increasing density of people. Elephants will be completely eradicated from the landscape if land transformation exceeds 40-50 percentage. In Australia, farmers have always considered kangaroos as pests, as they compete with sheep for forage and damage crops. Due to this the federal government of Australia authorizes the culling of a certain number of kangaroos every year. About nine million kangaroos are eliminated each year apart from

those killed by poachers and farmers (Therin, 2001). Distefano (2005) conducted case studies across Europe , Africa, North America and Asia, all of which showed that HWC is more intense in developing countries and tropics where agriculture and livestock are an important part of the income and livelihoods of rural people. Across these counties, fighting for the use of natural resources between wild animals and local communities is mainly direct and violent putting the resident human populations at risk. It is quite clear that indigenous people with low living standards are mostly at risk, similar to the agro-pastoralists who depend solely on the production and income of their land.

Fooks *et al*. (2014**)** described that across the world, hostility towards various wildlife species have been caused due to the risks of disease transmission from them. Farmers in the UK, for example, are concerned about badgers (Meles meles), which act as tuberculosis vectors for cattle, while red foxes are active in transmitting Echinococcus multiocularis, which is fatal to humans in the European mainland. In addition, a number of carnivorous species including skunks (Mephitis mephitis), raccoons (Procyon lotor) and bat-eared foxes (Otocyon megalotis) serve as rabies reservoirs that account for about 50,000 human deaths worldwide each year. Rambaut *et al*. (2004) reported that animals also have a zoonotic connection with one of mankind's most devastating diseases currently. As carriers of Simian Immunodeficiency Virus (SIV), African primates have been involved as the original source of Human Immunodeficiency Virus (HIV), which has a death rate of almost 100% and has infected more than 42 million people across the globe so far.

In addition, large carnivores are potentially hostile, large-scale and can sometimes kill human beings themselves, which creates reasonably strong hatred for their presence in areas of human settlement. A deep-seated hostility due to past experiences and an inherent fear of large predators also surround these factors, even if carnivores are not causing problems during then (Garland, 2008). Tsavo's man-eating lions, which killed 28 people in 1898-1899, are well known throughout the world, carnivores and man-eating lions still pose a real everyday

danger to many people today rather than an amusing historical tale (Baldus, 2006). In many countries, records of fatalities from wild animals are difficult to acquire or poorly organized, but countries with such data suggests that deaths from animals form a tiny minority of mortalities, e.g. 0.07 percentage in the U.S and 0.06 percentage in Norway, including domestic animals (Linnell *et al*., 2002). While the number of human deaths caused by wildlife is small in the global sense, relative to disease, famine and war, the severity of the conflict it creates can have very important impacts in terms of the animosity to conserving potentially dangerous species (Woodroffe et al., 2005).

Akenten (2015) highlighted that when people's interests and source of livelihoods are threatened, the upkeep of conservation is usually compromised. And such cases are more frequent in developing countries, as human populations are likely to undergo greater economic cost during conflicts. O'Connell-Rodwell *et al*. (2000) remarked that the costs of coexisting with wildlife were taken by themselves in many communities of Africa without receiving any benefits. In some African countries, for instance, peasant farmers took many aspects of wildlife conservation negatively because of the costs inflicted by dangerous wild animals and crop raiders. Moreover, farmers who lost crops to wild animals were against the conservation of wildlife (Kideghesho *et al.,* 2007). Armah *et al*. (2014) claimed that due to numerous conflicts that have surrounded it's use, management and conservation, the abundant natural resources of West Africa were gradually diminishing. The rural inhabitants of the mountain area of Simao, near the Xishuang Banna Nature Reserve in China claimed that their annual income was reduced by 28 to 48 percent in 2000 due to the damage caused by elephants, and that the total economic losses between 1996 and 1999 amounted to US$314 600 (Zang *et al*., 2003). In rural areas with livestock production as the major economic activity, the potential for human-wolf (*Canis lupus*) conflict exists, as all ungulate species including livestock are preyed upon by wolves (Mech and Boitani, 2010). Throughout the wolf range, such conflicts have been described, which contains most of the Northern hemisphere (Bibikov, 1982). Wolves in Alberta, Canada,

killed 2,806 domestic animals, mostly cattle and also others, pigs, chicken, dogs, horses, bison, geese, goats and turkeys during a 14-year period (1982–1996). Wolves have killed 728 livestock, mainly cattle and goats, during a short period of time (1987–2001) in the United States of Wyoming, Montana and Idaho (Musiani et al., 2003).

In response to the complaints on depredation, the government authorities in Alberta may resort to wolf control campaigns. Similarly, livestock producers of Canada also have the choice of killing wolves without the obligation of reporting kills (Gunson, 1992). There is always a positive correlation between the number of attacks on domestic animals with the number of wolves killed by authorities in the United States (Musiani *et al*., 2005). Human- wildlife conflict can cause opposition from some out spoken minority that can weaken the regional conservation initiatives and it is also seen as a major threat to the support for conservation from fringed communities (Naughton *et al*., 1999). Widespread elephant shooting and control were a part of the early management of wildlife in Africa. But even after a gradual decline in the population of African elephants (*Loxodonto africana*), they continued to be in conflict with farmers in many parts of Africa (Hoare, 1999). Acha *et al.* (2018) reported that villagers who lived near the protected areas of Ethiopia were killing large carnivores as a revenge of attack on humans by wildlife and loss of livestock. All villages were using deadly control means like shooting and trapping. The most serious issue in the region has been the killing of lions. Taking into account the actual pace of human population growth, increased competition for access to land and increased demand for natural resources, Mardaraj and Sethy (2015) claimed that the conflict between human and wildlife cannot be wiped out in the near future, but must be handled with high priority.

2.3 HUMAN-WILDLIFE CONFLICT- INDIAN SCENARIO

Human-animal conflicts are common in several parts of the country. In India, far more people are killed by wild elephants than leopard, tiger or lion. It is

surprising, however, that leopard-including human conflicts draw greater public attention compared to other animals. Tigers, lions and wolves, other carnivores known to have caused a huge number of human deaths in the past, are currently restricted to the forest area and their effect is therefore not as prevalent as that of the leopard (Dickman, 2009). Between 2015-2018, human-elephant conflict in India caused 373 elephant deaths and 1,713 human deaths by unnatural causes, including poaching and electrocution. The highest numbers of human casualties were reported in West Bengal (307 deaths), followed closely by Odisha (305). Electrocution of elephants is an alarming cause of concern in managing India's elephant population. According to the data since 2015, deaths due to all other causes, including poaching, train accidents and poisoning, added up to 147 (Ganesh, 2019).

Mardaraj and Sethy (2015) reported that during the twentieth century, the demand for cultivable land increased significantly with the accelerated population growth in India. Large parts of pastures, peripheral lands and forests were transformed to cultivation areas regardless of their suitability for sustained agriculture. Even today, the condition in rural areas is very much characterized by unsustainable and irrational land-use pattern. With the increasing illogical conversion of forest lands and their later encroachment, loss of habitats and degradation of habitat quality has drastically reduced the wildlife in the country resulting in the ecological dislocation of certain species over the time period. This has increased the conflicts between the surviving wildlife and people carrying out subsistence agriculture in the surrounding regions of potential wildlife habitats. Even in remote areas, the existing protected forests are not free from cattle grazing, human activities and overexploitation of resources. In many areas with large tracts of forests, due to accelerated developmental programmes such as hydro and irrigation projects and shifting cultivation, the situation is further compounded forcing animals into conflicts with human beings due to confinement. Although there is progress in rural community development, improvement of agricultural practices and technology, and approaches to

integrated forest management practices, these procedures alone will not support the achievement of long-term solutions to the above problems resulting in the formation of balanced natural systems.

The upsurge in human and livestock populations has generated pressure on all-natural resources in India. Most protected areas are degraded, fragmented and disturbed due to anthropogenic activities. To meet the increasing demand for cereals and other food products pastures, forests and wastelands have been brought under cultivation. Further alteration in landscapes has been brought in rural areas by unsustainable land-use patterns. Habitat modification in these ways has caused ecological dislocation of many wildlife species. Even though some species stray out of protected areas and cause damages to human life and property in varying degrees, some others have adapted to humans and have become locally superabundant (Mardaraj and Sethy, 2015). In Gir National Park and Sanctuary, escalating and intense conflicts with leopards (*Panthera pardus*) and Asian lions (*Panthera leo persica*) are due to the extensive and rapid change in land use including the conversion of great millet (*Pennisetum typhoides*) and groundnut (*Arachis hypogea*) fields into mango (*Mangifera indica*) and sugarcane (*Saccharum offinarum*) cultivation. These crops play a major role in influencing the abundance and natural distribution of wildlife communities and create favourable habitats for predators (Vijayan and Pati, 2002).

Anthropogenic pressures such as habitat loss, trapping and hunting are threatening all macaque species in India to greater or lesser degree. In return, humans are also affected by various troubles due to macaques, such as damage to household articles when they enter houses, crop- and kitchen-raiding, as well as occasional injuries and bites. Conversion to commercial plantations and shifting cultivation has led to serious impacts on the habitats of black and sun bear in the north-east states of India. Villagers living at the fringe of the forest were susceptible to conflicts. These kinds of observations may be because of scarcity of food for sloth bears and unsuitability of the available habitat due to continuous fragmentation and degradation of the habitat (Mardaraj and Sethy, 2015). In

Rajaji National Park in India the reasons for human-elephant conflict were reported by Williams *et al.* (2001). Competition for food was the major cause of all the casualties and elephant deaths were mainly due to train collision. For controlling the death of elephants, the speed of trains was reduced. Accidental deaths of leopard due to collision of train in Rajaji National Park, Uttarakhand (UK), was higher in males than in females (Ritesh, 2010).

Figure 1: The wild elephant that was found electrocuted after it came into contact with an illegal electric fence erected around a banana plantation at Bhavani Sagar Dam in Sirumugai, Coimbatore (Source: **The Hindu**, 2019).

From all places where elephants survive in disturbed and fragmented habitats, extensive crop-raiding is reported. From several states such as Gujarat, Uttar Pradesh, Punjab, Bihar, Rajasthan, West Bengal, Haryana, Madhya Pradesh, Karnataka, Maharashtra, Tamil Nadu, the problem of crop damage by nilgai, deer, wild boar and blackbuck is extensively reported but the data on the extent and nature of damage is very limited. Due to these problems of injury, conflict between man and wildlife is steadily growing and hence it greatly affects people's acceptance of conservation ideals (Mardaraj and Sethy, 2015).

In Gujarat, in the proximity of Gir National Park and Sanctuary, the leopard (*Panthera pardus*) and the Asian lion (*Panthera leo persica*) use the widespread plantations of mango and sugarcane to find water and shelter to hunt prey such as buffaloes, pigs, cows and dogs. Although leopards have reportedly preferred the plantations as permanent habitat and even breed in cultivated fields bordering the edge of the park, lions have spread out of the park and into plantations for over a week. Once again, the overlapping of human settlements with the home ranges of wild animals has resulted in attacks on labourers and farmers and cattle depredation. As livestock depredation has become common and the overall ability of the rural people to address the conflict is weak, their safety is threatened (Vijayan and Pati, 2002). Along the Tamil Nadu, Karnataka border, a study conducted in 10 villages estimated that the total loss to agricultural crops due to elephants was about Rs.1.5 lakhs annually (Sukumar, 1991). Mardaraj and Sethy (2015) claimed that the number of instances of crop raiding by elephants is increasing at alarming proportions, and while protecting their crops, the number of people killed in encounters with elephants are on a rise. In India, due to the presence of tigers, irrigation of fields at night by the villagers were regulated while many villagers reported hardships on having to share their houses with livestock to protect the stock from attacks (Mishra, 1997). In Lucknow, 19 varieties of sugarcane were consumed by Indian crested porcupine (*Hystrix indica*). It also acts as a pest on crops due to the fragmentation and degradation of forest habitat (Srivastava, 2000).

Seidenstecker (1976) has investigated the problem of depredation of livestock and man-killing by tigers. In Gir forests, lions take heavy toll on cattle annually and man-killing incidences are on the rise recently. Similarly, from several regions cases of stock and child lifting by wolves and leopards have been reported. Rural people cannot afford to have persistent livestock depredation by large carnivores and their cultivation raided by elephant, nilgai, deer, wild boar and blackbuck. It is a matter of survival and not simply a matter of attitude. Around many parks animal husbandry is a major livelihood and economic

activity. Often killing of domesticated livestock by carnivores is a serious problem. Such instances of conflict include killing of domesticated bovids, sheep, goats and equids by lions, tigers, leopards, snow leopards, dholes, wolves, brown bears, striped hyenas, and black bears. A major consequence of this conflict is the retaliatory killing of "problem predators" by humans. The perceptions of the local people on the losses incurred often appear to go beyond the actual value of the livestock killed by predators (Mardaraj and Sethy, 2015).

Mishra (1997) found that varieties of chickens, ducks and geese are the other domestic animals that were lost to predators like canids, smaller felids, mustelids, viverrids, and raptorial birds in South Asia. In many areas, crocodiles and otters are considered as serious threats to inland fisheries. Due to the progressively degraded and fragmented nature of the habitat and a scarcity of natural food for bears in the Nilgiri Range, the predatory behaviour of sloth bear appears to have changed. It has been confirmed that leopards and tigers are the major animal predators among wild carnivores, with the latter preying on large domestic animals such as buffaloes and cattle and the former on smaller animals such as sheep, goats and calves. Tigers were confirmed to be a major threat in villages located within and close to the reserve. Instead, Leopards avoided competition with tigers and went beyond the villages. Tigers have always been at the centre of people's social, economic, religious and cultural life in the Sunderbans. This is the case even today and also in the past. The conflict between tigers and humans in the Sunderbans rooted from the tigers' man-eating habits and the socio-economic condition of local people. Annually the overall loss due to large feline (tigers and leopards) depredation is reported to be nearly 12 percentage of the total family livestock. In the Kibber Wildlife Sanctuary of Himachal Pradesh, India, in 1995 about 18 percent of the total livestock were killed by wild carnivores, mainly snow leopards. Annually tigers killed around 618 heads of cattle on an average within an area of 413 km^2 in Bandhavgarh National Park (Dwivedi, 1982). In Kuala Selangor Nature Park, the pest behaviour of long-tailed macaques and human-macaque conflict (*Macaca fascicularis*) were

studied by Hambali *et al*. (2012). In north India, rhesus macaque (*Macaca mulatta*) and Hanuman langur (*Presbytis entellus*) are the two species that live in in close proximity to and did trouble to humans (Borries *et al*., 1999).

Worship of animals and plants has often been reported in some Indian regions as the primary reason why people do not mistreat large carnivores and show a positive attitude towards animals and natural reserves. Many species of wild herbivores are held responsible for raiding crops in these regions. Wild boar (*Sus scrofa*) and nilgai (*Boselaphus tragocamelus*) are reported to be the cause for at least 50 percentage of the damage, while other species as common langur (*Presbitys entellus*), sambar (*Cervus unicolor*), chital (*Axis axis*), parakeets (*Psittacula kremeri*) and rhesus monkey (*Macaca mulatta*) are accounted for the remaining. Nilgai tends to favour the degraded edges of forest villages and they usually raid crops in the evening (Mardaraj and Sethy, 2015). Around the Kibber Wildlife Sanctuary in Himachal Pradesh, despite the increasing conflict between wildlife and agro-pastoralists in proportion to the growing population of livestock, villagers did not resort to the killing of snow leopards, which are the main cause of the problem. Wild carnivores killed 18 percentage of the total livestock holding in 1995. Snow leopards caused almost all the deaths in the region and still they were not persecuted. Whatsoever, retaliatory actions were performed against the Tibetan wolf, whose pups were reported to have captured and killed in almost every year during the 1980s (Mishra, 1997).

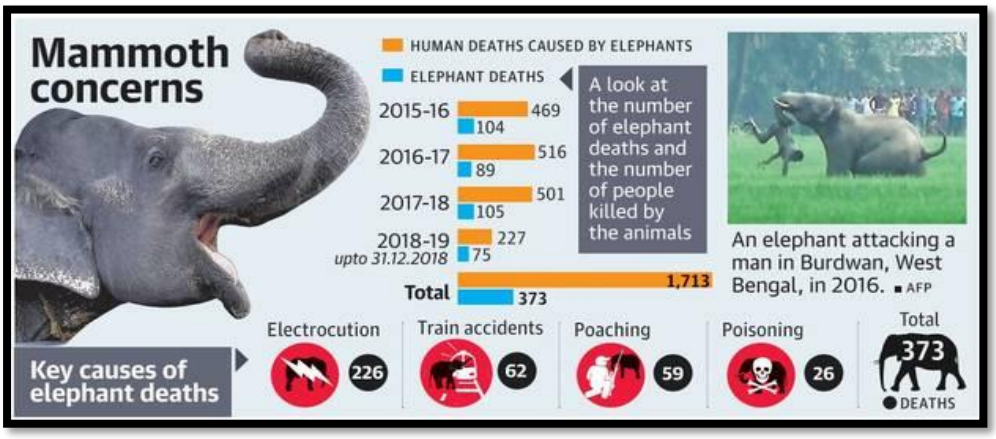

Figure 2: Data showing the mean number of elephant deaths per year (Source: The Hindu, 2019).

Conflict between human and wildlife reaches its gravest form when wild animals injure or kill people. Wild elephants in southern Asia are likely to kill more people than large carnivores, while wolves, big cats and bears in this area are readily targeted and recognized for such homicide.

Man-eating leopards, tigers, and wolves that rarely do child-lifting cause terror over entire regions, persuading antagonism against wildlife and massive retaliatory killings. In regions such as Bangladesh and the Sundarbans of India, the persistence and endemicity of man-eating tigers put forward that this acquired behaviour may be being transferred culturally through generations of animals (Sharma, 1997). In India about 100 to 200 people are killed by elephants each year (Santiapillai and Jackson, 1990). For man-eating tigers, the Sunderbans of eastern India has been a 'hotspot' for a long time with around 100 human deaths reported annually (Treves and Karanth, 2003). All the four species of bears in India, are in direct conflict with human beings in the form of casualties to humans, livestock depredations and economic loss from crops. Due to retaliatory killings to reduce livestock/crop depredation and poaching for bear parts, bears are now threatened (Mardaraj and Sethy, 2015). Effective habitat management and protection within the Gir National Park and Sanctuary has doubled the population of Asian lion *(Panthera leo persica)* between 1970 and 1993. The social structure, food requirements and habitat of the species inside the human-defined home range were hard to provide and resulted in many lions roaming out of the reserve into local villages (Vijayan and Pati, 2002).

The successful recovery of the near extinct or declining species population in the recent years, through protection from overexploitation and wildlife management has also led to new conflicts (Fall and Jackson, 2002). Karnataka's Bhadra Tiger Reserve hosts a population of 3000 people, as well as a significant number of mammalian fauna. The surveys and data collection carried out in the area between 1996 and 1999 gave evidence of resident villagers struggling from a high level of economic impact due to HWC (Barua et al., 2013). In 12 villages in the Ronghang-Hatikhuli area of central Assam's Nagaon district, although most

farmers do not have enough land to sustain their families, they donated 33 hectares of community land to plant paddy exclusively for the elephants that often come down the hills of the adjoining Karbi Anglong district. The "jumbo *kheti* (cropland)" has been envisaged as the last line of mealy defence against some 350-400 elephants venturing too close to human habitations. In the last 16 months, five of them were electrocuted by illegal electric fences while half a dozen, injured by spears and arrows, died in the jungles up the hills (Karmakar, 2019). Bist *et al*. (2002) argued that although the number of human deaths were reduced by the implementation of Project Elephant, the situation of damage on households and crop raids remained unchanged. It is also notable that in the recent years HWC studies on bats and birds have decreased. It does not mean that the dispute occurrences involving birds or bats have simply decreased in number because in 2016, the government of the Goa state discussed naming the peacock, India's national bird, as vermin so that it could be repressed for its crop raiding activities. (2016 The Telegraph).

Hence for both rural people and wildlife, the situation is quite tragic particularly in and around many of the managed forests and protected areas. Hence the development of strategies that can reduce the man-wildlife conflict to tolerable levels is imperative (Mardaraj and Sethy, 2015).

2.4 HUMAN-WILDLIFE CONFLICT- KERALA SCENARIO

As in other parts of the country and in other nations, human-wildlife conflict (HWC) is a controversial issue in the Western Ghats of Kerala. The greater attention for it in recent days is due to the human casualties caused by carnivores and the straying of wild animals in the crop fields. Among these, one of the major problems faced by the marginal farmers in Kerala is the crop damage by wild animals. The forests in Kerala are extremely fragmented due to the expansion of agriculture and settlements in the marginal areas. Due to this, in the agricultural fields adjacent to the forest areas, crop damage by wild animals became more common. Asian elephant, wild pig, sambar and Indian crested

porcupine were the major crop raiders recorded in the plantations and homesteads. The accessible habitat of wild animals in Kerala were reduced by past activities like shifting cultivation, largescale conversion of forests into monoculture plantations of eucalyptus and teak, organised encroachments and hydroelectric projects (Govind, 2015). Kuttoor (2019) reported that the forest ecosystem has been drastically altered by the granite quarries on the forest boarders. Boars and wild animals in Kerala frequently raid farms on the forest fringes at Seethathode, Chittar, Moozhiyar, Gavi, Pampa Valley, Neelipilav and Manpilav. Attacks on humans by leopards have also become common. Pathanamthitta has been witnessing frequent man-animal conflicts along the forest fringes, with 52.6 percentage of its geographical area comprising forests. Reports showed that the straying of wild animals into the workers' camps and human habitations at Pampa, Sabarimala, Nilackal and Attathode has increased. All these places were once habitats of wildlife.

According to Veeramani and Jayson (1995), since the enforcement of the Wildlife Protection Act (1972), indiscriminate poaching of wild animals has come down. Consequently, the frequency of crop damage by wild animals has increased in Kerala. During the period of 1983-1993, a study conducted in 20 randomly selected forest ranges of Kerala showed that tiger, panther and wild dog were commonly involved in cattle lifting. In twenty-one cases of cattle lifting and twenty-two attacks on goats, tigers were involved. Most of the incidences occurred during the day time when the cattle went for grazing in the forest areas. Majority of the attacks by panther were at night and they preyed upon cow, goat, pig and dog at places around the human habitations. A total of 64 injuries to human beings, 31 deaths and damages to two houses were reported during the period. A total of 30 human deaths were due to elephants, 27 by herds and 3 by solitary tuskers. One death was reported from the attack by Gaur in Parambikulam Wildlife Sanctuary. Attack by wild animals on people are normally reported from the forest fringes.

The study conducted by Jayson and Christopher (2008) revealed that the animals involved in crop damage in the areas surrounding Peppara Wildlife Sanctuary, were largely lone males, in the case of elephants and most of the raids took place during night. Observations said that more quantity of crops were damaged than what was consumed by the animals. Crops were attacked by wild boars in greater quantities than any other animals. Elephants and hare came next in the series. During the period of study, many instances of attacks by wild animals on humans were recorded.

Figure 3: A leopard scampers for cover from amid panic-stricken residents of a village at Chittar in Pathanamthitta (Source: Raman, 2019).

Prominent among them, was man slaughter by elephants. Four human deaths have been recorded from five encounters. A preference for tubers and tender shoots were shown in the case of tapioca. Elephants mainly damaged coconut and they preferred the trees below 20 years. They pushed down the trees below 10 years and consumed the shoots and central rachis. In plantains, elephants consumed the central portion of the stem and discarded the leaves. Paddy was lost due to wild boar, blossom headed parakeet, elephant and jungle fowl. Rolling and trampling by the animals created more waste in the field. Paddy was also destroyed by the elephants by trampling. Pineapple was destroyed by palm squirrels, palm civet, wild boar and elephants. Wild boar and elephant chose the central rachis and pineapple fruits, while palm squirrel and civet ate the fruits

only. Elephants trampled on and rooted rubber saplings, and fed on their basal parts. None of the animals hurt the betel nut trees or the cashew trees.

According to a theory, elephants follow the "high risk high reward" strategy in which males are expected to take high risks in their lives in return for gaining access to the highly nutritious food which will further improve their chances of getting more progenies and also better gene transfer (Sukumar and Gadgil, 1988). Contradicting the general belief that elephant tuskers are more aggressive deaths in HWC were more due to herds than solitary tuskers. Field observation in some areas showed that villagers entering the forest to collect Non-Timber Forest Products (NTFPs) like reed, honey, firewood and medicinal plants were also killed (Veeramani and Jayson, 1995).

Cash crops are also preferred by elephants since they are more nutritive (Sukumar, 1991). It is believed that the extensive attack on cash crops by wild boars may be also due to the same reason. At Peppara, around seven species of wild animals were involved in crop damage. Elephants and wild boars caused maximum damage among them. Plantains and tapioca were the main produces destroyed. Animals attacked the crops regularly as all the settlements were situated inside the sanctuary. However, the crop damage was low in places where the settlements were in cluster and agriculture not much innovative (Jayson and Christopher, 2008). Paddy feeding by pea fowl and other birds namely spotted dove (*Streptopelia chinensis*) and rose-ringed parakeet (*Psittacula krameri*) was recorded from the Wadakkencherry Forest Range. The terrain and vegetation of this range provided a suitable habitat for them (Jayson, 2013). Asian elephant (*Elephas maximus*), black-naped hare (*Lepus nigricollis*), sambar (*Rusa unicolor*), gaur (*Bos gaurus*), bonnet macaque (*Macaca radiata*), wild pig (*Sus scrofa*), common langur (*Presbytis entellus*), and Indian peafowl (*Pavo cristatus*) were the main animals involved in crop damage. Among these, the highest damage was caused by wild pig and Asian elephant. Only 8.2 percentage of the total compensation claimed by the farmers, was sanctioned by the Kerala Forest and Wildlife Department (Jayson, 1999).

Mainly, the wild animals clash with the local people. Tribals are seeing even less violence between humans and wildlife, where they are seriously affected as local populations. None of the tribals were among the four human deaths. All the victims were local citizens, who went to the forest to make a living. Also, local people hardly cared for the elephants and took least preventative measures against them (Jayson and Christopher, 2008). The settlements Kuravampara and Pothode has high literacy rates whereas Pattinipara has the maximum illiterates. There were more educated people in the peripheral settlements who were practicing modern agriculture with cash crops resulting in less incidences of crop damage in these areas. They were not interested in adopting conventional crop protection strategies such as watch-keeping and wards. Cultivation being their main source of occupation they will be severely affected by any occurrence of crop damage. The incidence of crop damage can also be associated with its economic situation. When families go through low income or fall in debt trap, they start commercial cash crop cultivation at the outsiders' provocation that leads to more crop damage and increased dissatisfaction. The traditional practice of people other than the Kanikkar marriage was a social custom, encouraging the incidence of crop damage. When outsiders marry a tribal girl they begin to stay in the settlements. With their little knowledge, they initiate the cultivation of crops like coconut and plantains. This leads to increased instances of crop damage. examples of such occurrences are at Kunnatheri, Amode and Cherumangal (Jayson and Christopher, 2008).

The highest number of injury cases were registered from Wayanad Wildlife Division compared to other divisions (Veeramani and Jayson, 1995). The escalating man-animal conflict in Wayanad with 143 deaths in 38 years, 82 in one region, is a worrying factor for the district (Manoj, 2019). A total amount of Rs.17,49,500 was claimed as compensation and the Forest Department sanctioned only Rs.1,25,150. In the Vazhachal and North Wayanad Divisions, the Forest Department has paid some money to the victims although there were no claims for compensation. In the whole of Kerala an amount of only Rs.2,95,000 was

sanctioned as compensation for total claim of Rs.20,64,900. In the previous studies, it was reported that only 8.2 percentage of the total ex-gratia claimed by the people was disbursed by the Kerala Forest Department (Veeramani and Jayson, 1995). It affected the attitude of farmers towards wildlife negatively (Veeramani and Jayson, 1995).

Figure 4: A boy killed by a leopard in Valparai, Tamil Nadu (Source: Jayson, 2013).

In order to reduce the crop damage, careful planting strategy and selection of crops is necessary. Crops like coconut and plantains in monoculture will accelerate the crop damage whereas the cultivation of crops like rubber and medicinal plants will increase the income of people and reduce the problem. Plantains or coconut were not cultivated while practicing shifting cultivation instead of that cereals and cassava were cultivated for nourishment. However, they initiated growing cash crops with the change in cultivation pattern, which became highly vulnerable (Jayson and Christopher, 2008). A permanent solution to the problem cannot be obtained by providing compensation to the victims of HWC. Arunachal Pradesh, Andhra Pradesh, Rajasthan and Manipur do not make any payment. Adequate compensations are not given for the crop damage even in Kerala. In the states which pay compensation, the amount varies from Rs. 2,000/-

to Rs. 10,000/ (Kothari *et al*., 1989). If more tribal are engaged in forest works than the non-tribal, who came from faraway places, human - wildlife conflicts can be reduced (Jayson and Christopher, 2008). Though pursuing preventive steps, Selling and Berk Muller (1988) indicate that most of these disputes can be alleviated if domestic stocks can be prevented from reaching national parks and sanctuaries where they are not eligible and wild animals can be restricted to areas designated for them. More awareness initiatives will be implemented to reduce human losses for the local population.

2.5 SEASONAL VARIATION IN HUMAN-WILDLIFE CONFLICT

Crop availability, seasonality, type and the phenological stage of the crop plays a vital role in the crop damaging behaviour of herbivores (Gross *et al*., 2018). Butler (2000) stated that seasonal raiding patterns have been associated with attraction to high nutrient quality, harvesting of specific crops and palatability, along with high water retention of cultivated crops and reduced chemical defences in comparison to seasonal reduction in wild grass availability, wild vegetation and quality and proximity between cultivation and boundaries of the protected area. Seasonal variation in forage quality for herbivores in tropical forests is generally low but tends to reach a minimum during the wet season. The emergence of annual crops that appear to grow synchronously with rainfall patterns and the availability of perennial crops all year round together make tropical forest areas ideal places for studying the effects of nutritional stress and changes in farmland supply on the timing of elephant raiding (Nchanji and Lawson, 1998).

Chiyo *et al*. (2005) reported that as phenology and growth of plants are dependent on rainfall distribution patterns, the abundance and food quality vary seasonally in most habitats. Body condition and nutrition of the herbivores are influenced by these variations. A hypothesis in the study conducted by Osborn and Parker (2003) says that a decline in the nutritive value and quality of natural forage causes nutritional stress which triggers the timing of crop raids by

elephants. The seasonal patterns in rainfall, according to the second hypothesis, decide the availability of crops at certain phenological stages which controls the temporal peaks in crop raiding behaviour. This study focuses on cultivated crops as a major factor in the segregation of foraging patterns from other ecological processes that occur in the natural habitat (Bhima, 1998). There is a coincidence between the peaks in crop ripening and decline in forage quality in the beginning of dry season in savannah habitats. This makes it difficult to separate the effects of crop ripening and decline in forage quality on the patterns of crop raiding (Osborn and Parker, 2003). The link between livestock depredation severity and seasonal changes is found to be high in the vicinity of the Sengwa Wildlife Research Area in Zimbabwe. Wild predators are more likely to draw attention and assault domestic animals during the dry season months when the vegetative cover does not support the surprise-based leopard and lion hunting strategies (Butler, 2000).

After conducting studies on the behaviour of eight wildlife species categories in different areas, Gross *et al*. reported that during the dry season, the number of damage events were lowest per month (Gross *et al*., 2018). In Meghauli VDC of Chitwan National park, Nepal the animals responsible for crop damage and the extent of crop damage differs with time and season. Paddy maturing time (July–November) and wheat or maize maturing time (March–June) were the two peak seasons for crop raiding in this region (Feng *et al*., 2012). Elephants travel long distances and disperse into larger areas particularly in the rainy season, when attractive crops like maize and many others are planted to exploit nutritious food sources (Shrader *et al*., 2012).

Depending on their habitat, the temporal distribution of crop damage by elephants has found to vary. Most of the crop damage occurs during the dry seasons in African forest habitats (Chiyo *et al*., 2005) whereas late wet season was identified as the main time for crop damage in savannah habitats. The nutritional value of the natural forage (crude protein and moisture content) is lower during these seasons relative to that of the plant crops (Osborn, 2004). The crucial time for wild elephants, according to Carisse and Kushalappa (1990), is summer, when

they attempt to attack nearby agricultural crops. During summer, the grasses in the forests are dead and burnt, most of the trees are without leaves and tanks and streams are with little or no water which makes the animals to move on to cultivated places. The devastation is particularly serious in areas adjacent to the forests with animals such as tiger, lion, primates, deer, and wild pigs. While elephant attacks were linked to the cultivated crop species, wild boar damage was reported all year round. Elephant attacks occurred when palatable crops such as coconut, plantain and areca nuts were planted (Jayson and Christopher, 2008).

In Zimbabwe, the diet of elephants shifted from grass in the wet season to mostly browse in the dry season. Similar patterns have been identified in a variety of studies conducted in East Africa and South Africa, such as (a) in the early wet season, there is little difference in nutrient quality between crops, grass and browse, (b) in the late wet season, grass quality decreases more rapidly than browse or crop quality, and (c) browse quality remains relatively constant between dry and wet seasons. The results of this study indicate that the quality of grass toward the end of the wet season and the onset of crop raiding are linked (Osborn, 2004).

The seasonal pattern of wolf depredation in Alberta, Canada is explained by the length of the grazing season. In Alberta, in relation to weather conditions, the grazing period varied between areas and years. Around May, profitable grazing typically began in these areas (Lodge, 1970). Grazing operations terminated in mid-October in most areas. Grazing took place up to December-January in a few areas. Finally, the least opportunities for grazing were provided in the months between February and April (Lodge, 1970). In Tamzania, zebra mainly caused harm in the rainy season, during which this migratory species has the highest density due to breeding in the Simanjiro plains of the study region (Rija and Hassan, 2011). During the rainy season, buffalo and zebra scatter further from water bodies like most herbivores when they are planted with staple crops (Ogutu *et al*., 2014). Marker *et al*. (2009) highlighted the human-leopard conflict

issues in India, its management and policy. The main cause of conflict was rearing of cattle and the highest occurrences were during the dry season.

2.6 CLIMATE CHANGE AND HUMAN-WILDLIFE CONFLICT

Although not mentioned often, they cannot be controlled, climatic trends are major reason for HWC instances (Distefano, 2005). With change in the climate, the character of extreme weather events, such as droughts and cold snaps, will also change, obliging relatively rapid changes in habitat for most animals (Root and Schneider, 2002). It is hard to predict or avoid these intermittent climate events, but they have an impact on those conflicts. An El Nino Southern Oscillation triggered a combination of causes, drought and fires during 1997-1998, which resulted in the destruction of large areas of Sumatran forests. During that period, near Berbak National Park, the tigers which were fleeing through the burning areas were reported to have killed a person (Nyhus and Tilson, 2004).

In Kenya, the predation intensity is directly correlated with seasonal changes in rainfall. Patterson *et al*. (2004) quantified a positive association between attacks and monthly rainfall in Tsavo National Parks, demonstrating that there the livestock were attacked by the lions more frequently during the seasonal rains. Ungulates spend nearly a small amount of freshwater sources during times of drought, making them easy to locate and kill, but when rain fills seasonal ponds, lions scatter into their habitat, alter their diets and prey on relatively easier targets (Patterson *et al*., 2004). In proximity to the Sengwa Wildlife Research Area in Zimbabwe, the correlation between intensity of livestock depredation and seasonal changes is also found to be strong (Mardaraj and Sethy, 2015). In central Canada, the northern extension of the porcupine's (*Erethizon dorsatum*) range has been accompanied by a warming poleward shift in the location of tree line (Payette 1987).

The observed changes in populations of animals and plants can be attributed to climate change, specifically to the increase in temperature since the patterns created by global warming are broad and large scale, generally

continuous rather than spotty and often predictable. Moreover, these changes are expected to intensify in areas where the temperature change is largest, and less evident in other places. Certainly, change of climate is only one among the long list of factors/phenomenon affecting the distribution of population, morphology, health, and other traits such as timing of activities. Many main factors include the destruction of natural and semi-natural environments, the trade of animals, human persecution (e.g., legal and illegal trapping, harassment), pollution, invasion, many civil wars and the introduction of invasive organisms, toxic contamination and physical obstructions such as highways, houses, farms and high towers. These localized pressures bring about certain changes which would create a pattern of response that is patchy and irregular, and often centred around quickly developing areas (Root and Schneider, 2002).

Dissimilar to the past, wild animals intruding the farm areas of Idukki, Kerala are now staying there for longer duration and destroying vast areas of land. Even if chased back into the forests, they come back in groups within a couple of days. In Munnar, the tea plantations area often frequented by wild animals and hence the local residents usually stay indoors during night. In the past two years. A number of incidences of man-animal conflicts were reported from these plantations. Human lives were lost in ten incidents. Areas mostly encroached on by wildlife are agricultural areas of Mankulam and Kanthallur, tea plantations of Munnar and the cardamom plantations of Udumbanchola taluk. According to the Forest Department officials, climate change and lack of fodder and water could be a reason, although the forest had ponds to provide drinking water. Forests are rich in water and fodder during the southwest monsoon season and wild animals do not venture out, but delayed rainfall force them to move out. Usually by June, wild elephants get enough fodder and water inside the forest. But, in 2019, the season was quite different and that would have caused their increased presence in the areas inhabited by humans. According to a farmer from Idukki, the claim that wild elephants keep inside the forests during monsoon season is wrong, instead they arrive in herds. Jayson (2016) found that fifty-five per cent of the total

human wild life conflicts were reported during the south-west monsoon (June-September). The Chinnar wildlife sanctuary which is undergoing a drought-like situation has severe shortage of fodder and water, which would have driven the wild elephants to outer areas of the forest, said sources from Forest Department. Normally after the northeast monsoon, the elephants move back to the Chinnar forest areas, but this year they found fodder in Kundakkadu, near Kanthallur and stayed there for long (Raman, 2019).

CHAPTER 3: MATERIALS AND METHODS

3.1 STUDY AREA

Wayanad district is located (Fig. 5) at southern top of the Deccan plateau and about 75 km away from Kozhikode. It lies between north latitude 11°26'28" and 11°58'35" and east longitude 75°47'50" and 76°26'35" and with an elevation of 700 to 2100 m.

The area is significant because of its ecological and geographic continuity. Wayanad district is having a geographical area of 2131 square km, from this total area rural area extends upto 2,090.26 square km and about 40.74 square kms from the urban area. The Kabani River drains the whole district with its tributaries, the Panamaram river, Mananthavady River and the Kalindi river (Gok**,** 2016).

According to 2011 Census, the total population of the district is 8, 17,420 persons with 49.14 male and 50.86 percent female respectively. Among them 31.24 percent is from tribal community.

Table 1. General population – Wayanad

Male	Percentage	Female	Percentage	Total
4,01684	49.14	4,15,736	50.86	8,17,420

Source: GOI, 2011

The sex ratio in the district is 1035. Forest area is divided into three regions: North Wayanad, South Wayanad Territorial Division & Wayanad Wildlife Division. Total area of the three-forest division constitutes 885.92 square km. Cultivation is widely practiced in the selected area of study. The selected study area settlements large number of cultivations is practiced. Main occupation is agriculture and the major crops are paddy, ginger, tapioca and plantains. In few

areas Forest Department have provided electric fencing for the protection of the settlements.

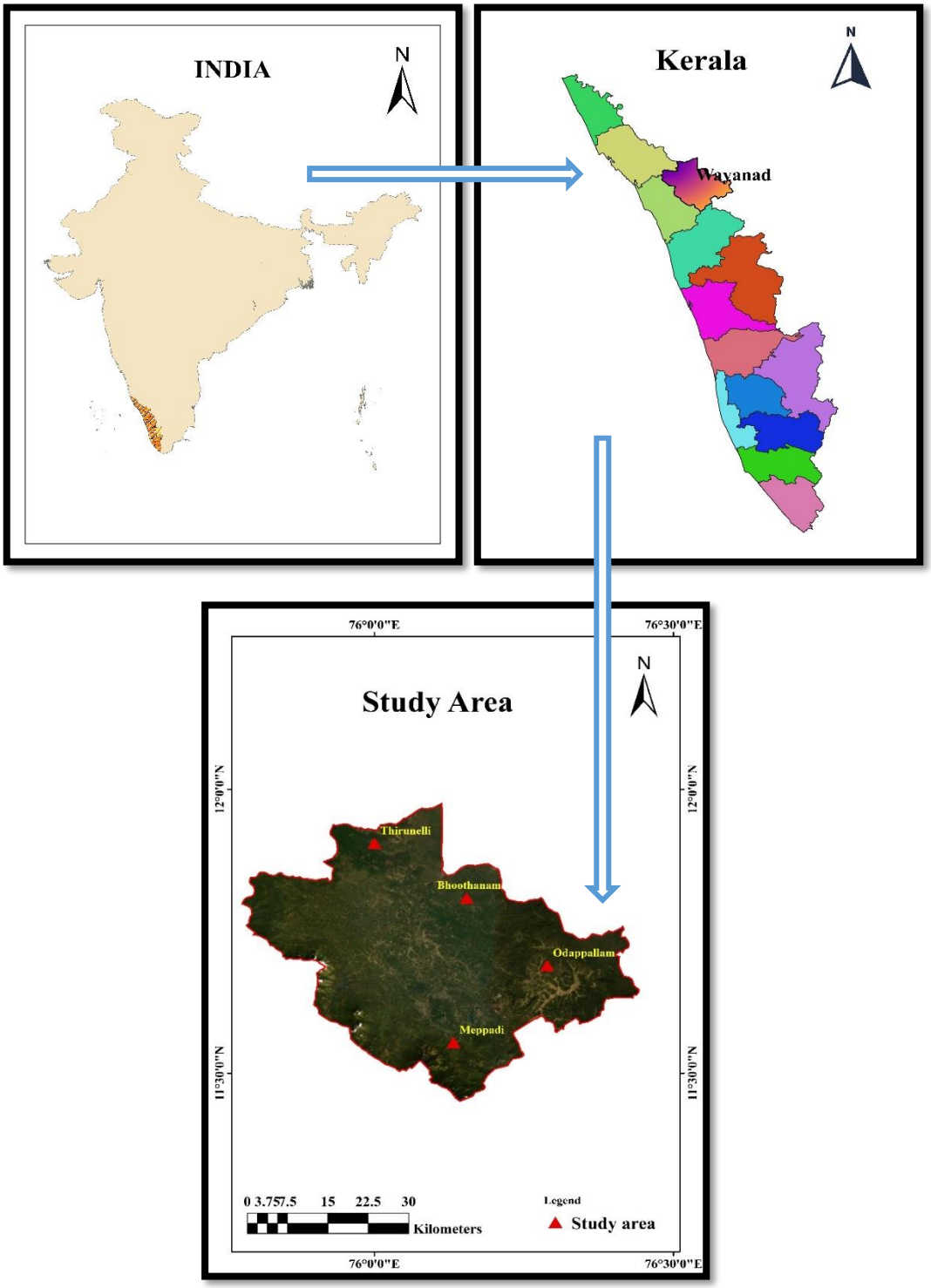

Figure 5. Location of the study area

3.2 Selection of sample

Mepadi, Odapallam, Bhoothathaam and Thirunelli were selected for the study because these places have been identified as vulnerable to human-wildlife conflict in the previous study conducted during the period 2016- 2017. (Ajaisankar, 2017).

3.3 Data Collection

Primary data collection

Detailed interview with a prepared questionnaire was conducted to gather information from the sample. A suitable interview schedule was prepared with the help of experts and pre- testing was done in few households of Pathrakandam, Thrissur to check the suitability of the prepared interview schedule. The pretested interview schedule was revised with suitable corrections to meet the objectives.

Information on the damages caused by the wildlife on the people's livelihood and the general characteristics of the instances was obtained during the survey. Open ended questions were also asked to get the people's perception on the causes of the instances and its seasonality.

Each of the sections was designed to describe various aspects concerned to the local community, such as:

i)Basic details

The socio-economic status of the individual is analysed by this section such as name, age, education, occupation and sex.

ii). Sources of livelihood and season of the activity

The section was included to know the major source of livelihood from which the family derives their income and the months of activity.

Table 2: Major source of livelihood and season of activity

Source of livelihood	Months Practised											
Agriculture	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Livestock												
Wage labour												
Forest products												
Plantations												
Other												

iii)Frequency of HWC instance

The number of occurrences of the human wildlife conflict in the past month was enquired. An account on nature of conflict experienced was accounted. It covered nature of conflict animal involved, frequency of occurrence, timing (Dusk, Dawn, Night) and weather condition of the day. Nature of conflict (crop raiding, lifting of cattle, injury to cattle, human death, injury to human, damage to assets and causal encounter).

iv) (a) Damages caused to the cropping systems and the months of occurrence

In this section crops which are raised and months which they are raised were recorded to find out whether the occurrences are crop specific or not.

(b) Stage of crop/year after planting also separately noted

(c) Type of damage: These accounts how wild animals caused damage to crops such as eaten and trampled.

v) Details of attacks on livestock

This part gives an account on animal attack by wild animals such as which animal is being attacked by wild animal, it's life stage (means juvenile/adult) its gender and how it is attacked killed or injured.

vi) Details on damage to property

This gives an idea of wild animal is attacking on property or on the populations asset such as building and vehicle. And a loss of money due to this conflict is collected.

vii) Attack on human

Questions were prepared for knowing attack towards human and its details like extent of injury (wounded/death), gender and age of the affected person.

The collected data was subjected to statistical analysis using SPSS (16.0) to find out the significant relationship between number of HWC incidences, nature of conflict, it's frequency and the weather parameters.

Secondary data collection

Instances of all HWCs that occurred in each month in these four areas were collected by contacting the concerned Range Officers and from the official records maintained on HWC instances in other related forest offices. Previous five-year data on HWCs pertaining to these four locations were also collected. Past five-year meteorological data (temperature and rainfall) of the study area was obtained from Regional Agricultural Research Station (RARS) Ambalavayal.

Statistical analysis

The primary and secondary data were further analysed for studying the seasonal variations in the nature and frequency of human-wildlife conflicts in these four HWC "hotspots" in Wayanad. Regression was done separately for each region with number of conflicts as dependent variable, rainfall (R.F) and temperature (T) as independent variables. Time series analysis was done to find the trend of temperature and rainfall in different years. The past five-year data was used (secondary data) to obtain a linear regression model.

CHAPTER 4: RESULTS AND DISCUSSION

The results of the study titled "Seasonality of human-wildlife conflicts in Wayanad, Kerala" are outlined and discussed here under.

4.1 SOCIO-DEMOGRAPHIC PROFILE

4.1.1. Gender

The gender wise distribution of the 131 respondents drawn from the four study areas, namely Meppadi, Odappallam, Bhoothanam and Thirunelli regions of Wayanad Wildlife Sanctuary (WLS) are given in Table 3. It can be seen that out of the 131 respondents interviewed, 64.12 percentage respondents were males and the rest were females.

Table 3. Gender wise distribution of respondents

Variables	Categories	No. of Respondents	Percentage	Total no. of Respondents
Gender	**Male**	84	64.12	**131**
	Female	47	35.87	

It was observed that out of the 131 respondents interviewed, a greater number of respondents belonged to the male category. A total of 36 from Meppadi, 33 from Odappallam, 32 from Bhoothanam and 30 from Thirunelli selected for respondents. At Meppadi, 23 respondents were male. At Odappallam, Bhoothanam and Thirunelli, 21, 24 and 16 males respectively were interviewed. In case of female respondents 13, 12, 8 and 14 were from Meppadi, Odappallam, Bhoothanam and Thirunelli respectively.

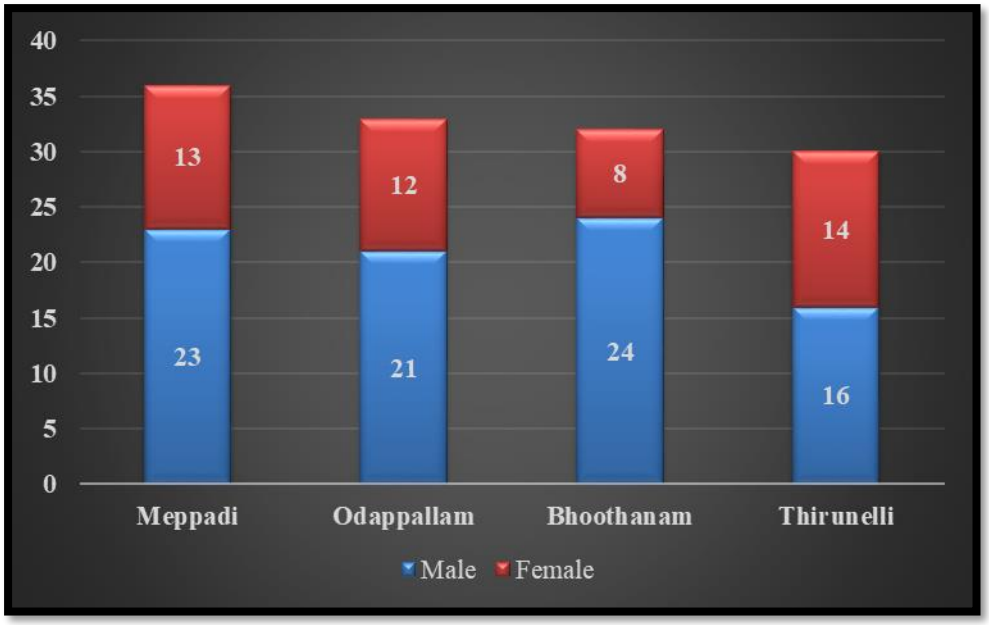

Figure 6. Location wise distribution of the respondents

4.1.2 Age

The age wise distribution of the respondents is presented in Table 4. Out of 131 respondents interviewed, 33.58 percent fell in the age group 'below 40 years' and 33.58 percentage came under '41- 60 years and 32.82 percent of people was under the 'above 70 years' category.

Table 4. Age wise distribution of respondents

Variables	Age Categories (Years)	No. of Respondents	Percentage	Total no. of Respondents
Age (Years)	<40	44	33.58	131
	41-60	44	33.58	
	>70	43	32.82	

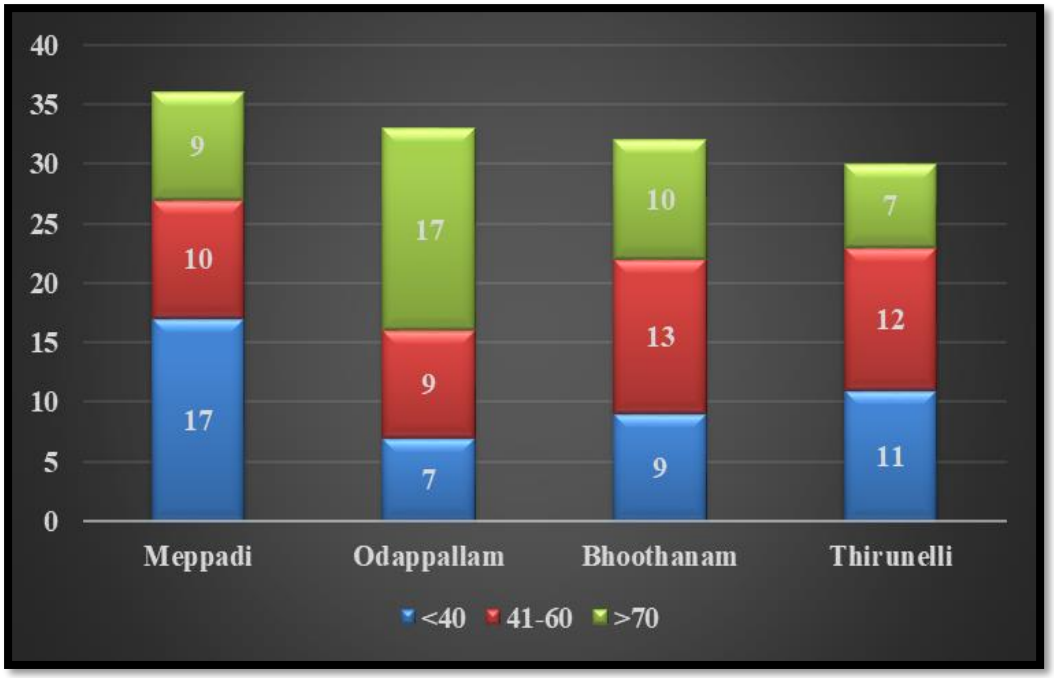

Figure 7. Location wise age distribution of respondents

Age wise distribution of the respondents from four areas is shown in Fig. 7. Out of the 131 respondents, 17 respondents from Meppadi, 7 from Odappallam, 9 from Bhoothanam and 11 from Thirunelli belonged to <40-year age category. Ten respondents from Meppadi, 9 from Odappallam, 13 from Bhoothanam and 12 from Thirunelli fell under 41-60-year age category, while 9 from Meppadi, 17 from Odappallam, 10 from Bhoothanam and 7 from Thirunelli who were interviewed came under >70-year age category.

4.1.3 Educational status

The educational status of the respondents from Meppadi, Odappallam, Bhoothanam and Thirunelli areas in Wayanad is given in Table 6. From the table, it is clear that, out of 131 respondents interviewed, 45.81 percent had primary education. Thirty four percent had high school education, while 18.32 percent people had plus two education. Only 1.52 percent respondents could acquire degree qualifications. However, none of the interviewed respondents was found to have a Post Graduate (PG) qualification.

Table 5. Educational level of respondents

Variable	Categories	No. of Respondents	Percentage	Total no. of Respondents
Educational Status	Primary	60	45.81	131
	High-School	45	34.35	
	Plus Two	24	18.32	
	Under Graduate	2	1.52	
	Post Graduate	0	0	

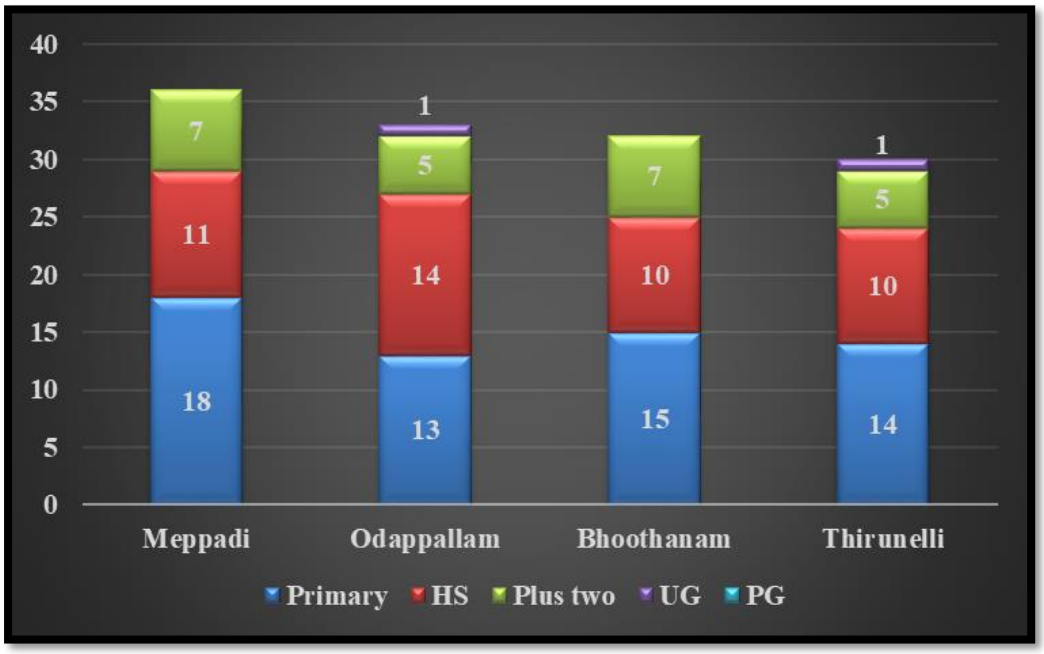

Figure 8. Location wise educational status of the respondents

The educational status data showed that 18 respondents from Meppadi, 13 from Odappallam, 15 from Bhoothanam and 14 from Thirunelli had primary education. Eleven respondents from Meppadi, 14 from Odappallam, 10 from Bhoothanam

and 10 from Thirunelli had high school education. Meanwhile 7 respondents from Meppadi, 5 from Odappallam, 7 from Bhoothanam and 5 from Thirunelli had higher secondary level education. In Odappallam and Thirunelli, there was one degree holder. None of the interviewed respondents had PG qualification.

4.1.4 Occupational status

The respondent's occupational status in the study area is outlined in Table 6. Out of the 131 respondents, the maximum number of respondents came under the 'farmer' category (31.29 percentage), while 18.32 percent had private jobs. The wage labourers comprised 28.24 percent of the interviewed respondents, while the rest of the respondents (22.13 percentage) were included in the "others" category (These people were not having a steady job, but involved in odd jobs).

Table 6. Occupational status of respondents

Variable	Categories	No. of Respondents	Percentage	Total no. of Respondents
Occupation Status	**Farmer**	41	31.29	**131**
	Private	24	18.32	
	Wage Labour	37	28.24	
	Others	29	22.13	

The occupational status of the respondents is shown in Fig. 9. There are 4 respondents from Meppadi, 13 from Odappallam, 15 from Bhoothanam and 9 from Thirunelli who reported that their occupation was farming. Eight respondents from Meppadi, 9 from Odappallam, 4 from Bhoothanam and 3 from Thirunelli had private jobs, while 18 from Meppadi, 1 from Odappallam, 8 from Bhoothanam and 10 from Thirunelli were wage laborers. Six respondents from

Meppadi, 10 respondents from Odappallam, 5 respondents from Bhoothanam and 8 respondents from Thirunelli were involved in odd jobs.

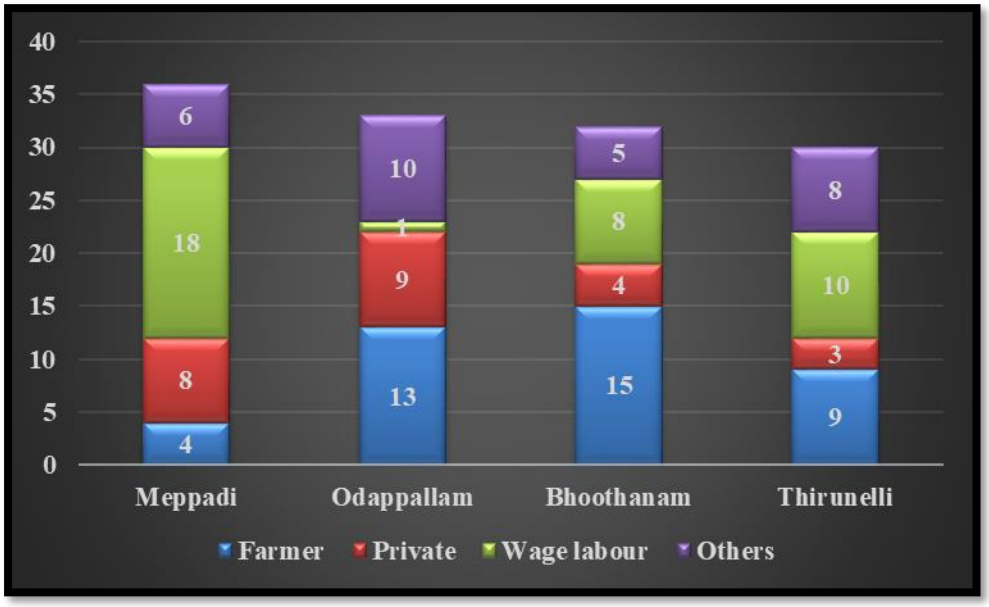

Figure 9: Location wise occupational status of the respondents

4.2. HUMAN WILDLIFE CONFLICT

Being largely an agrarian district, most of the rural population in Wayanad district is dependent mainly on agriculture for their livelihoods. Wayanad being a high-altitude region also favours the cultivation of coffee, tea and many other plantation crops. Moreover, the farmers in the respective conflict areas of Wayanad district also are involved in a mixed cropping system which includes, among other species, coconut, areca nut, banana and jack fruit. The other major crops which are cultivated in the region are paddy, ginger, millet, pepper, coffee, vegetables, and tapioca, which incidentally are also the plant species which the crop raiding wildlife mostly prefers. Majority of these cropped areas as well as the respondents identified for this study was also living in close proximity to forest area. As a result, the chances of interaction between these respondents and wild animals are quite frequent and high. The results of the observations on the HWCs in the four study areas are presented and discussed in the Figs. 10 to 17. At Meppadi (Fig. 10), based on analysis of primary and secondary data, it is evident

that, crop raiding is the major HWC issue, followed by damages to house and properties.

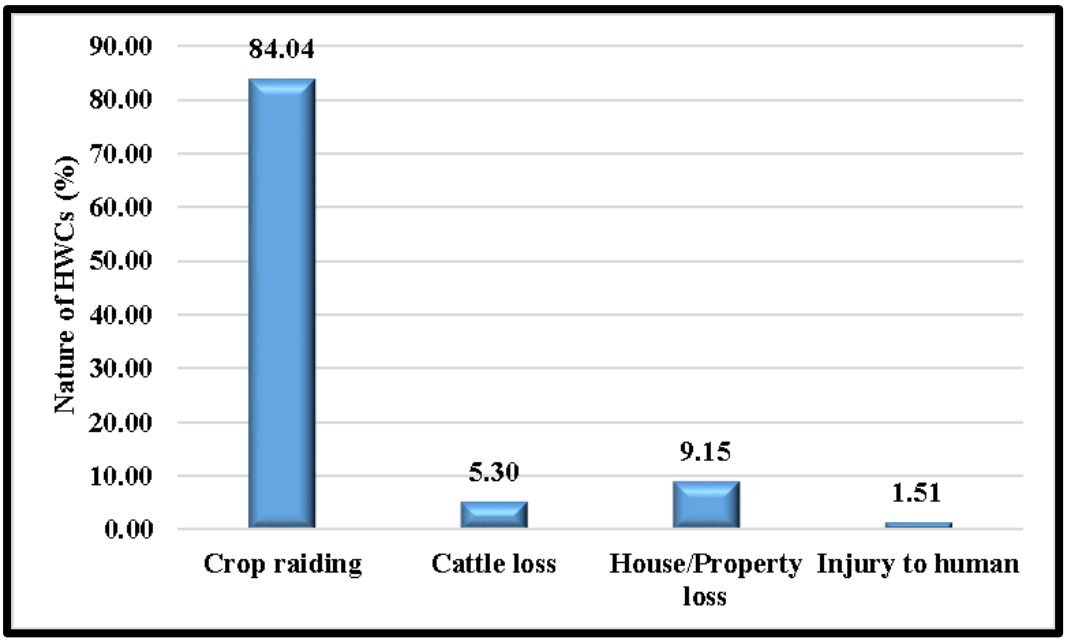

Figure 10. Nature of HWCs in Meppadi

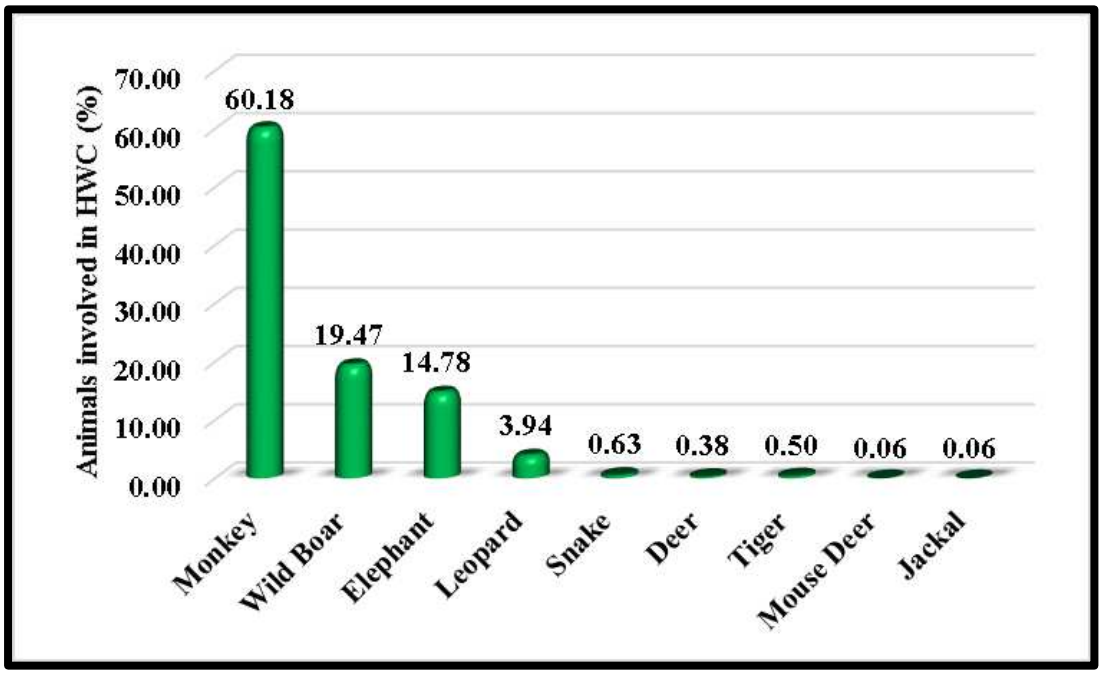

Figure 11. Animals involved in HWCs at Meppadi

Interestingly at Meppadi (Fig. 11), bonnet macaques are the most frequently interacting wildlife, followed by wild boars and elephants. As can be seen in Fig. 10, crop raiding is the most important issue at Meppady involving wildlife. The respondents at Meppady have pointed out the frequent presence of all these three mammals in their farm lands. According to the primary and secondary data collected as a part of this study, macaques are involved in the destruction of cultivated food and fruits crops, teasing human beings and at times causing harm to the tourists and pilgrims passing through. In a similar study at Himachal Pradesh, Sahoo and Mohnot (2004) had reported that the attack by monkeys was the major issue faced by the farmers in fringe areas of the forest there. Siex and Struhsaker (1999) highlighted the adaptability, intellect and opportunistic existence of certain primate species, allowing these animals in many tropical countries to be considered a serious threat to agriculture. According to Reddy and Chander (2016), monkeys are leaving forests and are migrating constantly to urban, semi urban and rural areas and 'monkey management' is the major challenging issue, faced by the forest and wildlife managers of India today. In Meppadi too, macaques pose management challenges to the field staff. As monkeys in general have strong cultural and religious associations, in such scenarios, conflict mitigation becomes challenging (Anand *et al*., 2018).

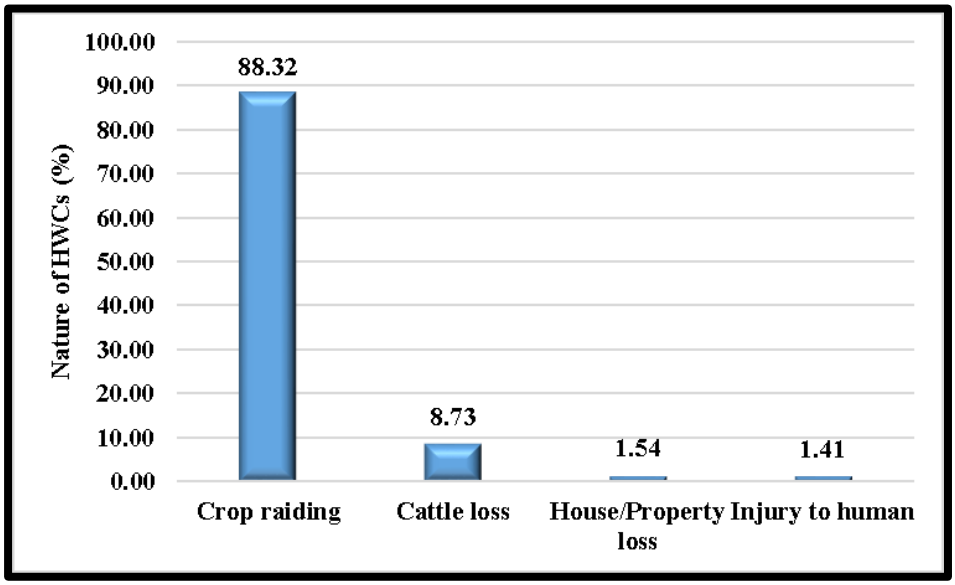

Figure 12. Nature of HWCs in Odappallam

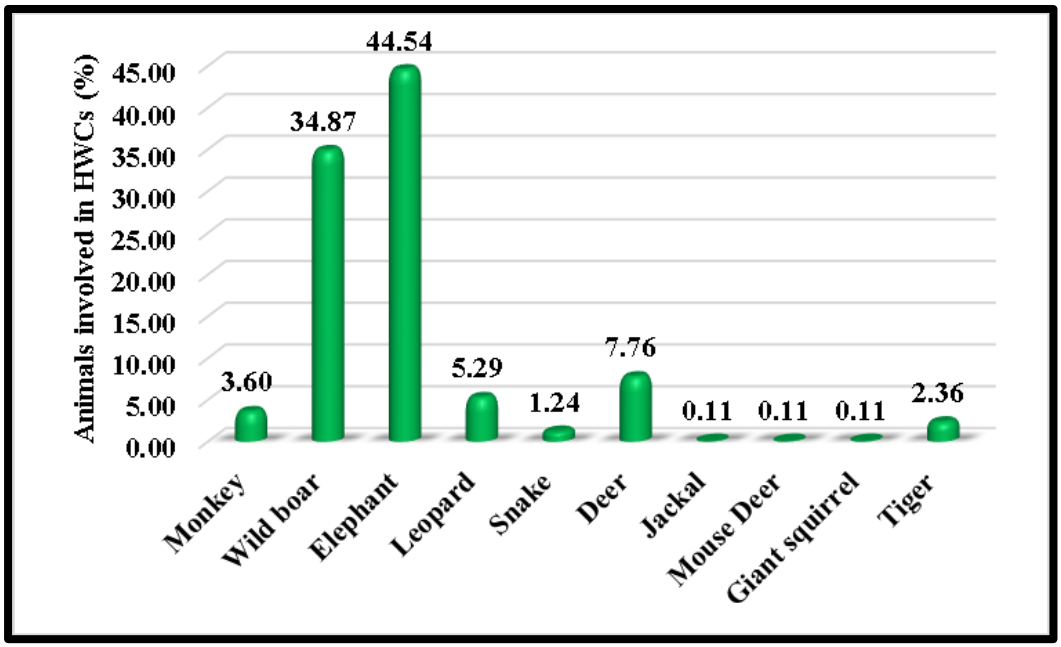

Figure 13. Animals involved in HWCs at Odappallam

In general, many of the respondents were observed to be still unwilling to cause harm to the macaques and this attitude coupled with strict enforcement of wildlife laws has favoured the macaques in their negative interactions with humans at Meppadi. At Odappallam (Fig. 12), based on the analysis of primary and secondary data, crop raiding was the major issue followed by livestock predation and loss of house or property.

In addition, livestock predation was an important issue which was reported by the respondents. In India, farm animals often graze on areas under wildlife sanctuaries (73 percentage) and protected areas (39 percentage) (Mishra, 1997). Hence, livestock becomes a major source of prey for the predators (Mardaraj and Sethy, 2015). However, though no forest grazing by the domesticated livestock was observed here, the relatively larger population of livestock in the forest fringes perhaps is an easy prey for the larger predators like leopards. The presence of leopards here was also evident in the collected data (Fig. 13). In the tiger nation, this large carnivore also occupies prime habitat, and thus leopards are often sent to marginal forests to escape direct chances of competition, which can also result in increased depredation of livestock in peripheral areas (Rajendra *et al*., 2019). Leopards, although they prey on a wide range of species, from arthropods to adult

sambar *(Rusa unicolor*) or gaur (*Bos gaurus*) (Seidensticker, 1976), they generally prefer prey species weighing between 10–40 kg (Hayward *et al*., 2006) and 2–25 kg (Lovari *et al*., 2013).

However, here too, elephants pose the majority of threats, followed by wild boar and deer. Shannon *et al*. (2009) is of the view that it is very difficult to determine the exact factors which influence the distribution of elephants in forest fringes. The availability of water resources and grass production might depend on the variations in the climatic conditions, which attract the elephants to a particular habitat. Hence, it will ultimately result in the increased human elephant conflict in the particular region by varying one of these above factors. While, the wild boar *Sus scrofa* is an omnivore which is considered to have one of the largest geographical ranges of all species. Researchers who have investigated their diet patterns have consistently observed that crops represent an important component. Among animal foods, it also included amphibians, reptiles, gastropods and myriapods along with insects, earthworms, birds and mammals (Schley and Roper, 2003). Major factors influencing food selection by wild boars are Energy requirements, food availability, and seasonal and geographical variations.

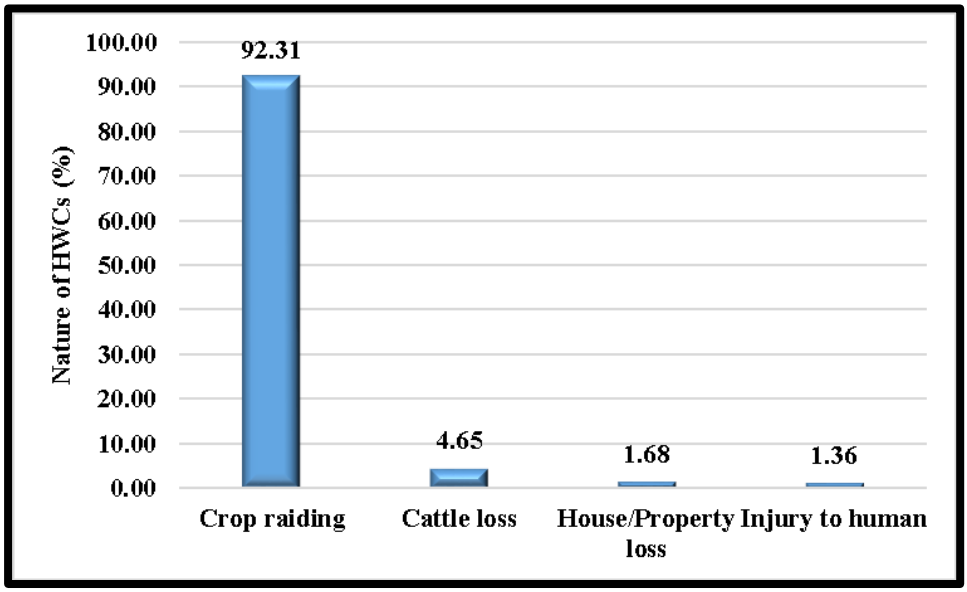

Figure 14. Nature of HWCs in Bhoothanam

These factors may also interact with human activities (e.g. agricultural crops, supplementary feeding) to further influence their diet composition (Ballari and

García, 2014). All these factors might have contributed to the increased interaction of this species in the agro-ecosystems at Odappallam.

At Bhoothanam (Fig. 14), crop raiding was the major issue, followed by livestock predation and damages to property and households.

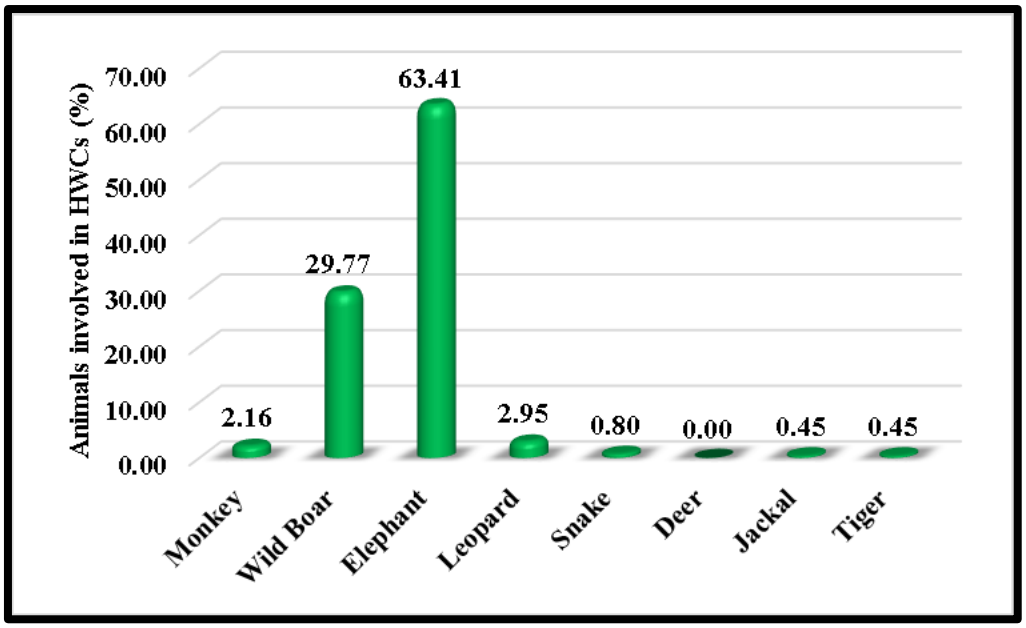

Figure 15. Animals involved in HWCs at Bhoothanam

Like at Odappallam (Fig. 13), the data point out elephants and wild boars as the major animals involved in HWCs. Also, most of the conflicts are reported during night time and it affects the farming of major crops like tapioca, banana, plantain and vegetables. Elephants, the respondents said, raided mostly cereals, fruits, legumes and vegetables as these large mammals are one among the leading conflict causing species comparing to other animals (Acharya *et al*., 2016; Gubbi, 2012). Apart from elephant, the other animals raid primarily tubers and legumes. Chiyo et al. (2005) reported that the relative frequency of damage to different crop types was substantially different across species of wild herbivores. Seasonal shifts have been cited as a significant factor in shaping wildlife crop consumption (Webber et al., 2011). Generally speaking, crops are most attractive to elephants when harvested and prepared for drying. The maturation period for staple crops, such as rice or maize (a time span that only lasts 1–3 months of crop production)

is also highly sensitive (Gross et al., 2018). Respondents also reported slight damages to houses by elephants. According to Balasubramanian *et al*. (1995), elephant raiding was most intensified during the ripening period of crops such as the millets and rice. Moreover, elephants having access to the abundant natural forage would also raid crops in the settlement area. However, Osborn (2004) is of the view that crop damage by herbivores occur throughout the year and changes according to the seasonal variations. The food source preferences to herbivores can be determined by the extend of consumption and avoidance (Iason and Villalba, 2006). In addition, at Bhoothanam, leopards were reported as the third species responsible for HWC in terms of attacks on people and livestock. Livestock are easy preys and animal houses are often poorly protected in the particular area against the attack of different carnivores. Another factor is that leopard have wide ranging behaviour due to large habitat requirements resulting in increased chances of conflict with humans residing in adjoining areas of forest (Manral *et al*., 2016).

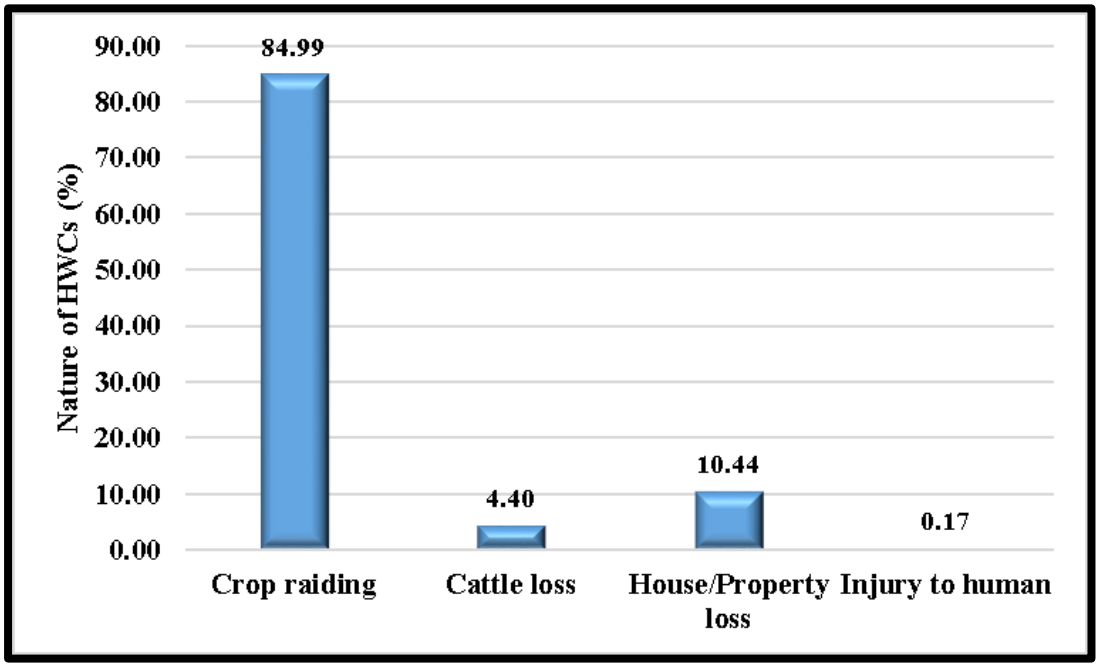

Figure 16. Nature of HWCs in Thirunelli

At Thirunelli (Fig. 16), crop raiding was the major issue reported followed by house and property damage and livestock predation.

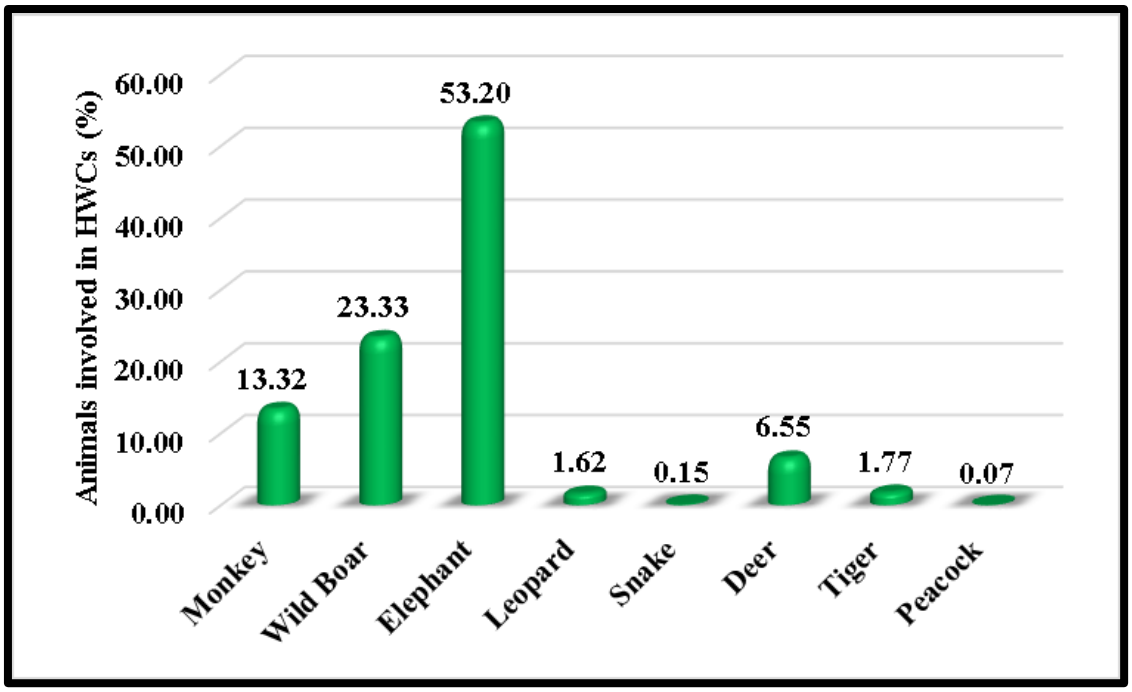

Figure.17: Animals involved in HWCs at Thirunelli

Elephants are responsible for the majority of the crop raiding instances here, followed by wild boars and bonnet macaques (Fig. 17). As already pointed out on earlier instances, the elephant's special foraging strategy for feed always results in severe damage to farms. Moreover, the intensity of their raiding also changes according to the seasonal variations (Young *et al*., 2009). HWC issues like livestock predation and destruction of households are also reported from Thirunelli region. During the interview, the people also reported that, the number and type of conflicts varied according to the changes in the season. Cropping season has a potential influence on the wildlife conflicts, particularly in the fruiting time (Hulme *et al*., 2018). Hence loss of mature, ready to harvest crops creates huge economic losses for the poor and marginal farmers of the Thirunelli region. At the same time, such negative interactions between wildlife and humans create animosity towards wildlife conservation efforts which may trigger negative emotions against wildlife (Gross *et al*., 2018). It was also identified that, there was

an unavailability of proper mitigation measures, which could make the problem worse. Moreover, cultivated crops are the major source of forage for the elephants and they are highly palatable for consumption. They have higher quantity of protein and essential nutrients as compared to the coarse and wild grasses (Patrick *et al*., 2005). There are reports which indicated that, the rate of occurrence of conflict by elephants and wild boars are higher during the harvest season of different crops on the field (Gross *et al*., 2018). The respondents also reported about increasing instances of attack involving the tiger at Thirunelli region. This might be due to the increased livestock population in the respective area which will attract this and other carnivores to livestock predation.

In Wayanad region, highest crop raiding was reported in the months of July to August. The monsoon season in Kerala will start at this time and influences the fruiting of many crops in the region. Similarly, highest number of encounters was during the monsoon season which is June to September. Sukumar *et al*. (1989) reported that, in dry season (January - April), browsing was important for elephants and rainy season is the most suitable time for consuming freshly growing tall grass. When the tall grass becomes unpalatable, they go in search of protein rich fodder during the winter season which is from the months of October to December. Osborn (2004) reported a crop-raiding frequency increase during October to December that could be explained by a 'push' factor of a reduction in the available wild forage as well as a 'pull' factor of irrigated crop maturation. Lower quality and decreased availability of natural forage between the late wet and early dry seasons often promote crop raids in settled human areas. There were differences in crop raiding events, frequencies and there was an increased HWC in the monsoon season. From the study, it was identified that, there are so many factors in an environment which are likely to affect the intensity of HWC incidents. These can include the characteristics of the natural habitat, seasonal variations, land use management, type of cropping and the type of animals. In addition, seasonal variations have played a potential role by substantially altering the possibility of HWC. The adoption of potential preventive and remedial

measures are need of the hour for the conservation of our remaining natural resources and for the promotion of sustainable natural resource management.

4.3. SEASONALITY OF HUMAN-WILDLIFE CONFLICTS

4.3.1. Temperature

The trend of temperature over the past five years in Wayanad is represented in Fig. 18. It is clearly evident that the year 2016 experienced noticeably high temperature, compared to the other years under study. The increase in average surface temperature over Wayanad during 2016 could be attributed to the increase in mean maximum and minimum temperature. The mean maximum temperature was 32.0˚C while mean minimum temperature was 21.1˚C during January 2016. While mean maximum temperature recorded during December 2015 did not show an increase during the successive month (January 2016), but the minimum temperature escalated by a margin of 1.2˚C, which led to the increase in average temperature during January 2016.

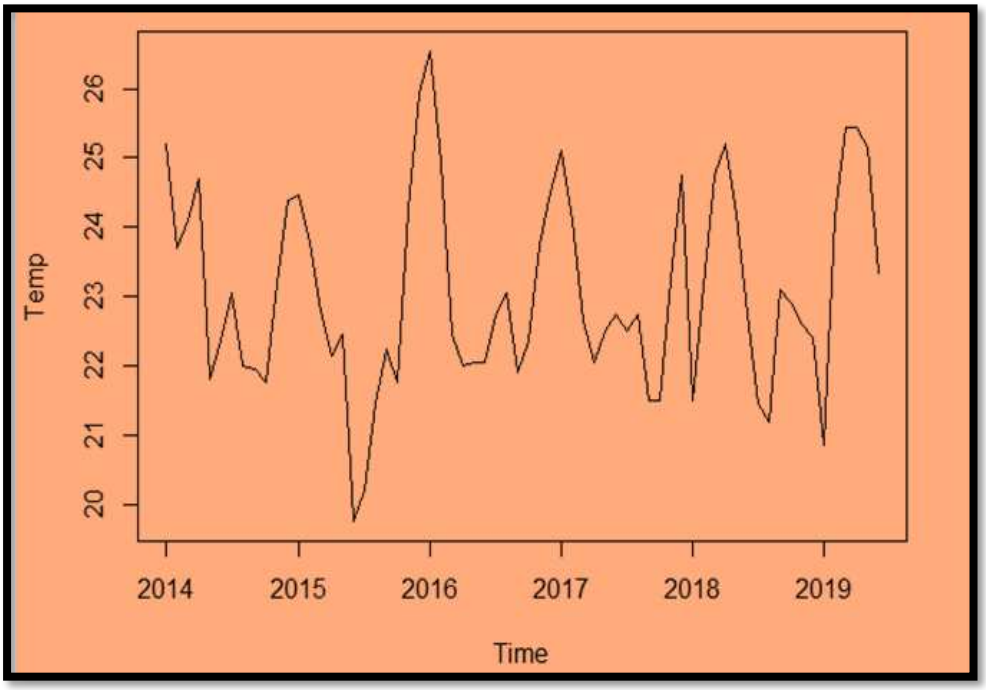

Figure 18: Temporal variations in average temperature in Wayanad over a five-year period

The year 2016 was also a drought year due to the failure of rainfall. The Fig. 18 depicts the rainfall variability over a five-year period. Here too, it can be seen that rainfall was highly deficient in 2016, while 2018 received the maximum amount of rainfall.

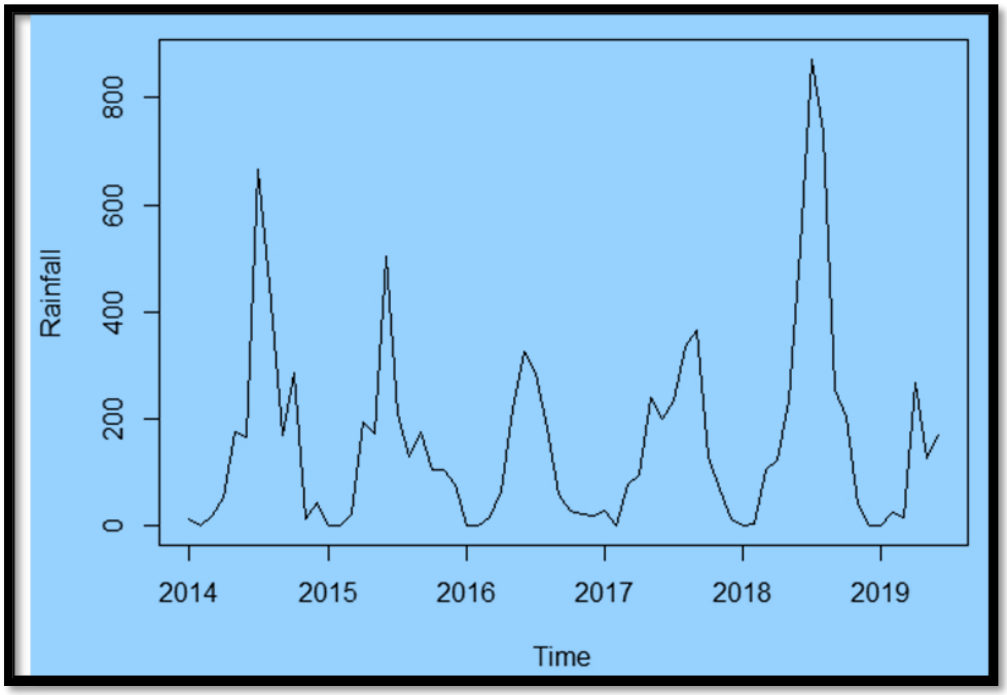

Figure 19: Temporal variations in rainfall in Wayanad over a five year period

4.4. HWC INCIDENTS BETWEEN 2014-2018

Fig. 20 shows the annual average number of conflicts in Wayanad district for the 2014 to 2018 period. The highest number of conflicts was reported in 2018 and the lowest number in 2016.

Connecting this HWC data with the temporal data on temperature (Fig. 18) and rainfall (Fig. 19), it can be observed that the year with the highest amount of rainfall also reported the highest number of HWC instances (Fig. 20). At the same time, the year with the maximum temperature (2016) recorded the lowest instances (136) of HWCs. Normally, incidences of human wildlife conflict were very less in the summer season, as the animals translocate nearer to the available

food and water resources (Patterson *et al*., 2004). In Kerala, in an earlier study, Jayson (2016) had reported that fifty five per cent of the total HWCs occurred during the south-west monsoon (June-September). Meanwhile, Barnes *et al*. (2005) had observed that crop raiding by elephants were frequent during the rainy season (May to June) and it was the time when crops reach their optimum maturity. In the study sites at Wayanad also, the increased HWCs, especially those involving elephants might be due to the fruiting of jackfruit in rainy season. Ajaisanker (2017) had also reported the same reason for increased human elephant conflict at a particular season in Wayanad district. Under eastern tropical climatic condition, reproductive phase in jackfruit starts from October and continues till February (Kishore, 2018).

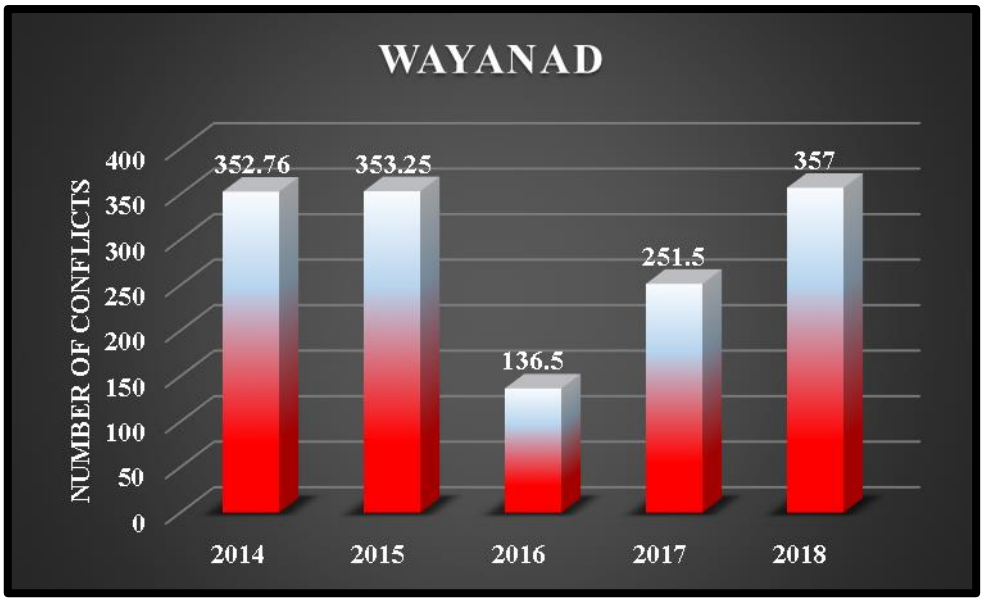

Figure 20. Average number of HWCs (2014-2018)

The study area had maximum rainfall during the southwest monsoon season and this also coincides with the planting season in June. Cultivation will be completed by the end of November. Moreover, paddy is one of the main field crops in all the study locations, being the staple food crop. Other crops such as banana, sugarcane and maize are also cultivated during this season of the year. Gross *et al*. (2018) is of the view that seasonality, availability of crop, type and the crop's phenological stage seem to play a major role in crop damaging behaviour of the herbivores.

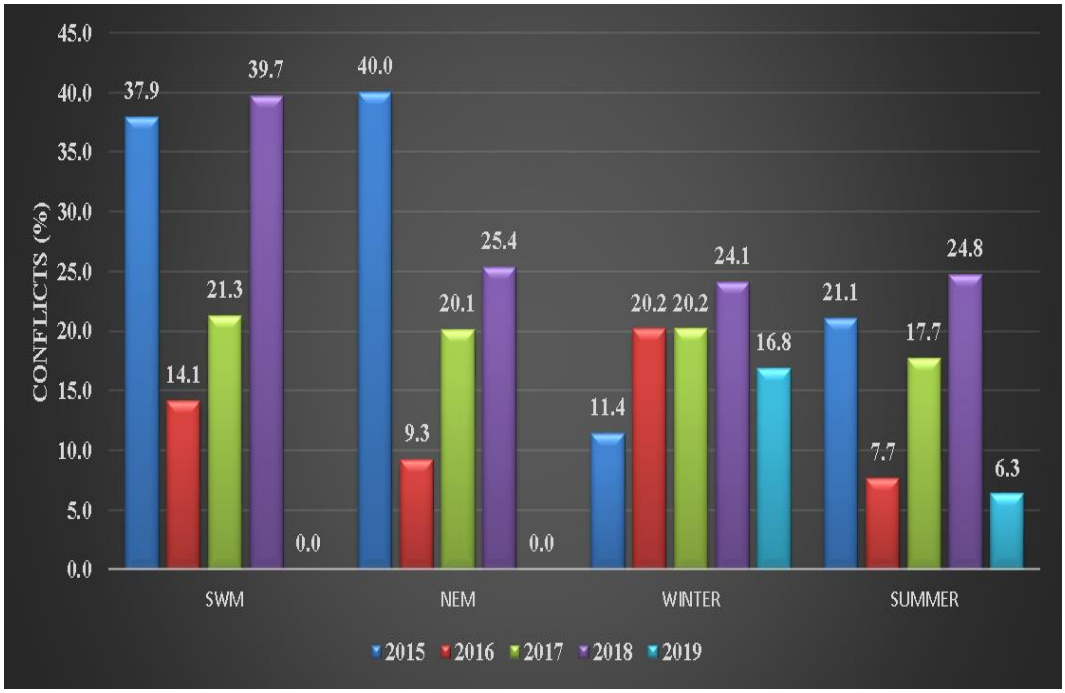

Figure 21. Seasonal variations in HWC incidences

According to them, crop consumers such as elephants (*Loxodonta africana* and *Elephas maximus*), zebra (*Equus quagga spp*.) and boars/hogs (*Sus scrofa*, *Potamocherus larvatus* and *Phacochoerus africanus*) show preferences for harvested and/or maturing crops. Rhinos (*Rhinoceros unicornis*) and antelopes/deer (*Taurotragus oryx*, *Aepyceros melampus*, *Boselaphus tragocamelus* and *Axis axis*) damage the highest numbers of fields with crops at an intermediate growth stage. Hence, the sufficient availability of palatable plant resources at a place and plentiful water might be a driver of increased HWCs in the southwest monsoon season. Wayanad also receives showers from the northeast monsoon which occurs from October to November. In the succeeding months of December to February, temperature falls in Wayanad. From Fig. 21, it is clear that, incidences of HWCs in the four study areas at Wayanad are more in the monsoon season, compared to the winter and summer season. Seasonal variations, especially those of rainfall and temperature have an influential role in HWC instances in Wayanad region.

Table 7. Correlation between the number of HWCs and weather parameters

Climatic Variables	Bhoothanam	Meppadi	Thirunelli	Odappallam
Temperature	-0.808**	-0.839**	-0.565	0.402
Rainfall	0.789**	0.997**	0.622*	-0.215

* indicates (P value <0.05)

** indicates (P value < 0.01)

The above table (7) shows the correlation between the number of HWCs and temperature and rainfall of the study area. There is a strong significantly negative correlation between number of conflicts and average temperature. Ironically, a positive trend was observed in the Odappallam region. Similarly, the number of conflicts positively and significantly correlated with rainfall (Figs. 19 & 21). But, in the case of Odappallam, an opposite relationship was found. Here a negative trend with the rainfall pattern was recorded. From the field visit and survey conducted in the Odappallam area, it could be understood that this could be due to the lesser number of human settlements and agricultural practices in the particular location. The number of conflicts of Bhoothanam and Meppadi region highly correlated with the temperature and rainfall. Similar case was reported by Mardaraj and Sethy (2015), who observed strong correlation between intensity of livestock depredation and seasonal changes in case of the Sengwa Wildlife Research Area in Zimbabwe. Likewise, Raman et. al. (2019) noted that, when the Chinnar wildlife sanctuary experienced a drought like situation, the severe shortage of water and fodder triggered the migration of the wild species to outer areas of the forest.

4.5. PREDICTIVE RELATIONSHIPS BETWEEN HWCS AND SELECTED WEATHER VARIABLES

The changes in the occurrence of HWCs are mainly affected by the variations in the weather parameters, particularly temperature and rainfall pattern. Also, the conflicts are most intense typically in the area of human settlement where the sphere of activity of the people, their livestock and wildlife overlaps. HWC was significantly correlated to the variations in temperature and rainfall pattern in most of the study locations.

Regression Analysis

Linear Regression Model (LRM) was fitted for the four study areas with number of conflicts as dependent variable and the average temperature (^oC) and total rainfall (mm) as independent variables.

In Bhoothanam, LRM was found to be significant (P value <0.05) and the model explains 91.33 percentage (R^2 = .9133) of the total variance. The fitted linear regression model equation was;

No: of conflicts (Y) = 109.78 – 4.21 (T) +0.02 (R.F)

The number of conflicts can be predicted through this regression prediction equation.

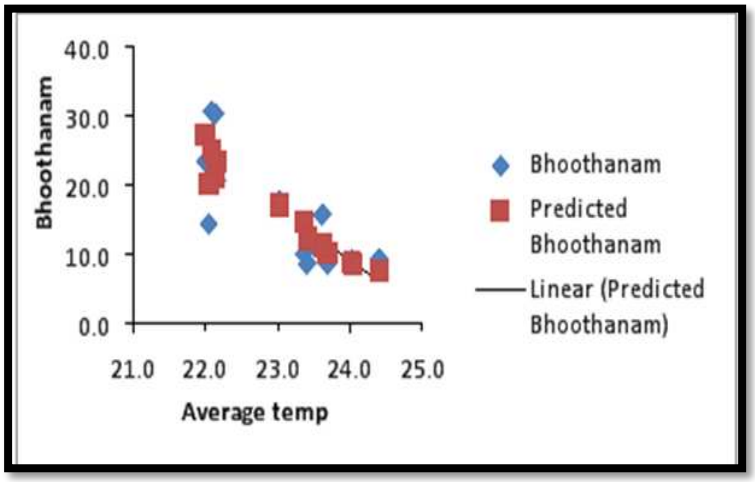

Figure 22 Average temp Line Fit Plot

Fig. 22 represents the line of fit plot for the independent variable (temperature) from the LRM and it showed a negative trend.

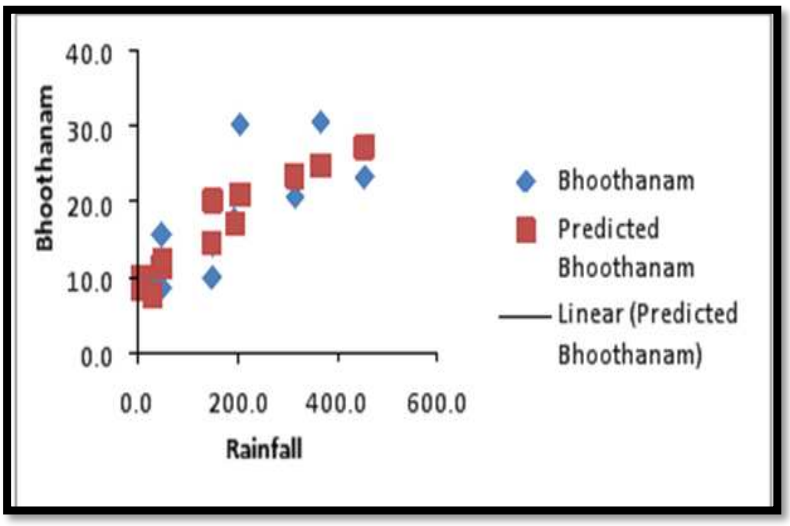

Figure 23. Rainfall Line Fit Plot

Fig. 23 represents the line of fit plot for the independent variable (rainfall) l from the LRM and it showed a positive trend.

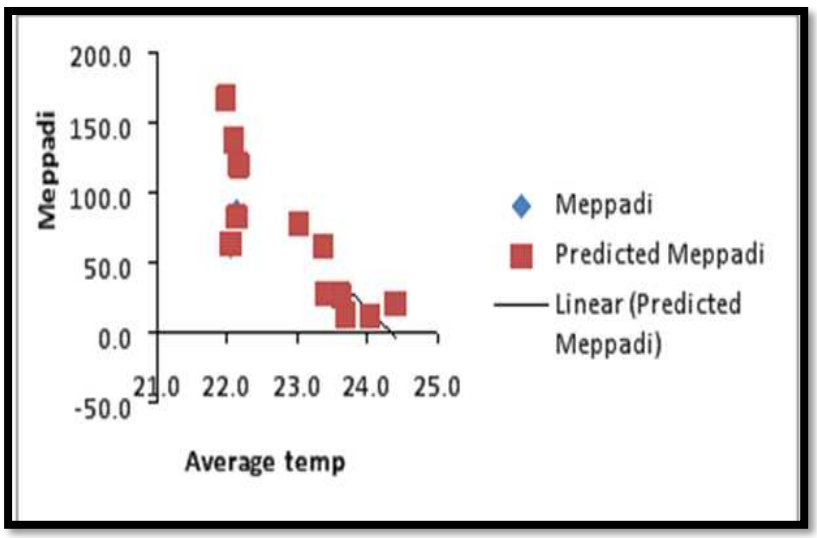

Figure 24. Average temp Line Fit Plot

Fig. 24 represents the average temperature line fit plot and it showed a negative trend.

In Meppadi, LRM was found to be significant (P value <0.05) and the model explains 99 percentage (R^2 = .9999) of the total variance A Linear regression Model was developed and the fitted linear regression model equation was;

No: of conflicts (Y) = 36.59 – 1.07 (T) +0.34 (R.F)

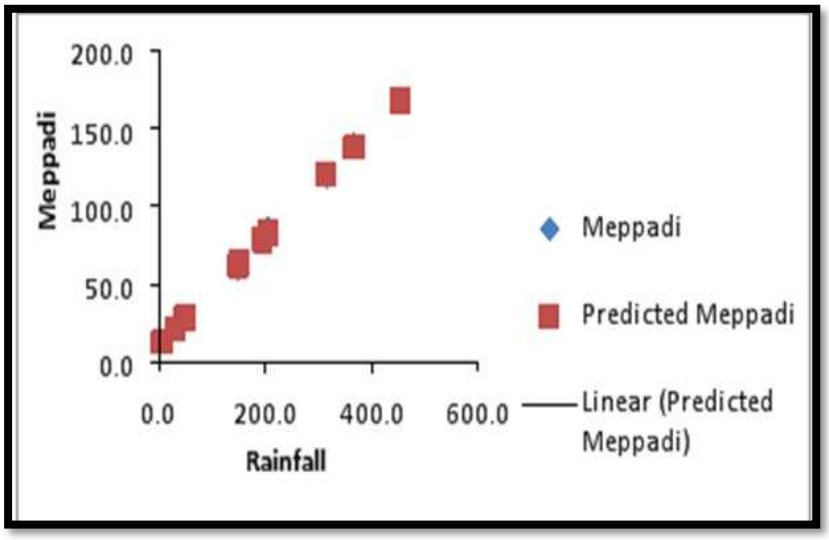

Figure 25 Rainfall Line Fit Plot

Fig. 25 represents the rainfall line fit plot and it showed a positive trend.

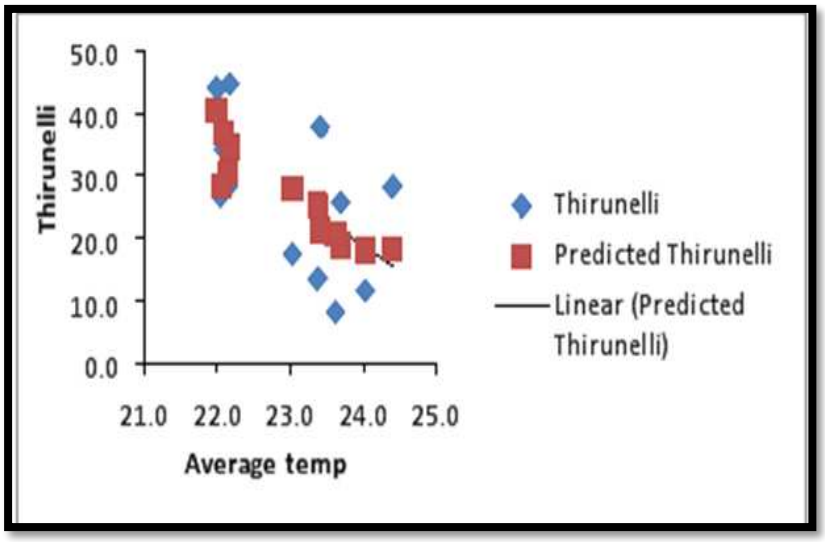

Figure 26 Average temp Line Fit Plot

In Thirunelli, LRM was found to be significant (P value <0.05) and the model explains 82.4 percentage (R^2 = .8249) of the total variance. The fitted linear regression model equation was:

No: of conflicts (Y) = 71.42 – 2.22 (T) +0.04 (R.F)

Fig. 26 represents the line of fit plot for the independent variable, namely temperature, from the LRM and it showed a negative trend.

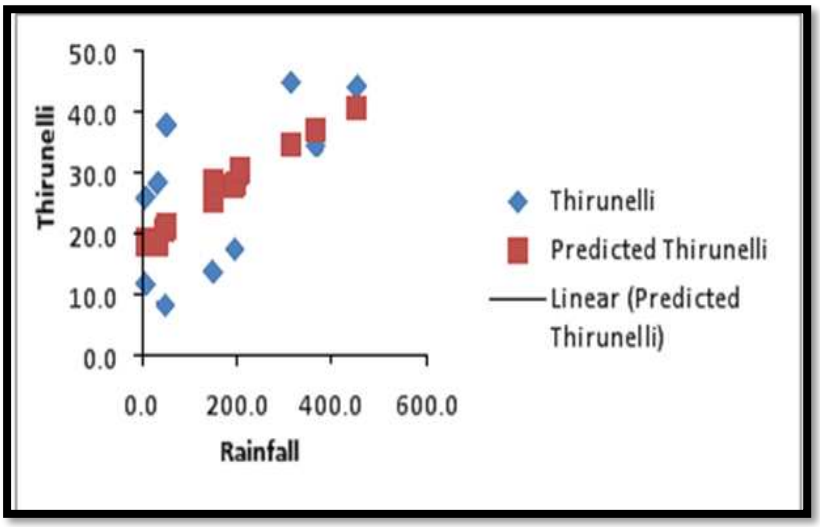

Figure 27. Rainfall Line Fit Plot

Fig. 27 represents the line of fit plot for the independent variable rainfall from the LRM and it showed a positive trend.

However, the linear regression was found to be not significant in the case of Odappallam (P value =0.35; R^2 is 0.2252).

The model shows that the temperature positively influenced the number of conflicts while the rainfall negatively influenced the number of instances, which incidentally goes against the trend observed in the other three areas. But variability in resource distribution across landscapes and inter-specific species differences and use of these resources can lead to unequal distribution of conflicts throughout landscapes (Sitati et al., 2003). In addition, the temperatures can increase habitat desiccation (Ogutu et al., 2008), which in turn can increase HWC

by raising the scarcity and herbivorous movements in search of water and high-quality food.

CHAPTER 5: SUMMARY

Based on this study, it can be concluded that the major wildlife involved in HWCs in all the four study locations in Wayanad are the elephant, monkey and wild boar. Crop raiding was the most rampant type of conflict involving wildlife, and instances of livestock predation, damage to house or property and injury to human, although much less frequent, were also not uncommon. In the current study, the high incidences of crop damages could be attributable to the proximity of crop fields to the forest fringes. Additionally, the farming of palatable crops and crop combinations too are influencing migration of wildlife to human habitations and farms. Several researchers have demonstrated the linkage between the various phenological phases of crops and timing of crop raiding by several wildlife species involved in HWCs. This factor too might have acted as a potential trigger in Wayanad which needs to be scientifically investigated and established. Better forest protection has decreased the threats to wildlife which in turn has stabilized their populations and increased competitions. At the same time, in Wayanad, human induced land use changes and climate change have also impacted the natural habitats of many wildlife. In the struggle for the "survival of the fittest" many wild animals are also forced to "step out" and search for resources outside forest boundaries.

Rising global temperature and over exploitation of natural resources have resulted in the decline of biodiversity. The interaction between climate and wildlife can result into human-wildlife conflicts (HWCs) of varying forms such as like crop raiding, livestock depredation and property damages. From the study, there was a significant increase in the number of HWCs during rainy season rather than the dry season in most of the study locations. In most of the study locations, under rising temperatures, HWCs showed a decline. Several cultivated crops reach maturity during the rainfall months. The wild animals are able to sense and time their attack during this period.

Human-wildlife conflicts create negative impacts on rural communities by causing severe economic losses from agricultural and associated practices. Intensive damage of crops and the increase in the frequency of attacks on humans and livestock systems by animals may soon force the rural peoples to reduce their tolerance to the negative interactions by wildlife. Mitigating of human-wildlife conflict thus becomes one of the key issues of concern for both forest officials and the scientific community. There is need to create an enabling environment for them to address the situation and also to strengthen their capacities in the most effective and efficient way. Adopting advanced mitigation measures is the need of the hour. Similarly, advanced and eco-friendly measures including Information and Communications Technology (ICT) enabled early detection and warning systems, solar fencing, elephant proof trench, establishing rehabilitation centres, encourage group farming, constituting wildlife squads, advanced Global Positioning System (GPS) for animals and ensuring waste management and long-term mitigation measures are to be implemented in the particular area. Constructing a wildlife information centre which provides information about HWC is essential for mitigating the effects of human-wildlife conflicts.

Future line of work

- The study can be extended to prolonged period of time and effect of climate change can also be observed.
- More climate parameters can be included to the study.
- Seasonal and crop wise HWC study can be considered.
- Land use changes and it effect on HWC can be studied.
- Seasonal and species wise HWC can be considered.

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APPENDIX

Title of the study: Seasonality of human wildlife conflicts in Wayanad, Kerala.

1. Basic Details

Respondent no:
Date:
Location:

i) Name:

ii) House Name:

iii) Panchayat:

iv) Gender:

v) Age:

vi)

Household Members:		
Male:	Female:	Children:

vii) Primary Occupation:

viii) Education: Primary/ High School/ Plus Two/ Under Graduate/ Post Graduate/ Illiterate

ix) How long has been residing here (Years)?

x) Distance of site from forest boundary?

2. Main sources of livelihood and season of the activity

Source of livelihood	Months Practised											
Agriculture	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Livestock												
Wage labour												
Forest products												
Plantations												
Other												

3. In the last 30 days/ 1 month did you experience any HWC instance?

4. Nature of conflict

Sl. No.	Nature of Conflict	Animal Involved	Frequency (24X7)	Timing: Dawn, Night, Dusk, Day
1	Crop Raiding	**i)**		
2	Lifting of Cattle	**i)**		
3	Injury to Cattle	**i)**		
4	Human Death	**i)**		
5	Injury to Human	**i)**		
6	Damage to assets	**i)**		

4 i) Crop Raiding

Crop Raised	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Stage of Crop:

Type of Damage: a) Eaten

b) Trampled

c) Others…….

ii) Cattle Attacks

Species:

Stage: Juvenile/ Adult

Gender:

How affected: a) Died

b) Injured

iii) Damage to Property

What property or asset has been affected?

How much loss occurred?

iv) Attack on Human

Extend of injury

Gender: Female/ Male

Age of the affected person?

SEASONALTY OF HUMAN WILDLIFE CONFLICTS IN WAYANAD, KERALA

by

KARTHIK KRISHNAN M.G.

(2014-20-126)

ABSTRACT

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ABSTRACT

Human wildlife conflict can be described as any interaction between humans and wildlife that may result in any kind of harm to either former or the later. Rising global temperature and over exploitation of natural resources have resulted in the destruction of biodiversity. The interaction between climate and wildlife can results into human-wildlife conflict (HWC) of varying forms such as like crop raiding, livestock depredation and property damages. In this context, this study aims to analyse the seasonal variations in the nature and frequency of human-wildlife conflicts in the forest fringe areas of Meppadi, Odappallam, Bhoothanam and Thirunelli areas in Wayanad district, Kerala. The study showed that there is a significant increase in the number of HWCs occurred during rainy season rather than the dry season in most of the study locations and under rising temperatures HWCs showed a decline. Crop raiding was the most rampant type of conflict involving wildlife, and instances of livestock predation, damage to house or property and injury to human, although much less frequent, were also not uncommon. The forest fringes were the major problem prone area as found out by the study and crop raiding was the major issue. Also, the maximum number of HWC instances are reported in the months of June to September, indicating the southwest monsoon period needs more attention.