International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 5 Issue 12|| December 2016 || PP. 55-60

The Limit of Chill Method as a Non-Lethal Deterrent in Mitigating Human Elephant Conflict in Serengeti Ecosystem

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Abstract: *Despite the popularity of chill method in mitigating human-elephant conflict (HEC) in crops fields of areas adjacent or within unfenced protected areas ecosystem in Africa countries, there are some challenges facing application of the method resulting to food insecurity. The study aimed at examining limitation of chill method in mitigating HEC using Western Serengeti ecosystem in Tanzania as a case study. Data were collected by using Survey and Participatory Rural Appraisal (PRA) methods. Collected data were analysed by using statistical package for social scientists (SPSS) software. The study revealed that human elephant conflicts were a big problem in two selected villages (namely Nyamburi and Bonchugu) for about 97%. In trying to solve the problem different mitigation measures were used by the local people to prevent elephants (Loxodontaafricanaafricana) from crops fields whereas chill method despite of its challenges seems to be effectives for about 83%. Major challenges which limit/hinder chill method in mitigating human elephant conflicts includes pepper types, availability and their effectiveness in producing chocking smell; weather conditions; and changing behaviour of elephants (Loxodontaafricanaafricana).*

Keywords: *Crop raid, Human elephant conflict (HEC), chilling method.*

I. Introduction

Human–elephant conflict (HEC) is one of the serious challenges to the wildlife researchers, wildlife managers, conservationists, local communities and elephants alike. It is common to all areas where elephants and human population coexist as well as share resources (Distefano, 2005).In Tanzania human elephant conflicts is increasing as human populations and agriculture expand into elephant habitat (*ibid).* Elephants continue to threaten farmer's income and food security despite considerable research and resources that has been devoted to resolving this problem (Woodroffe *et al.,* 2005).In Serengeti district HEC is more alarming (Kaswamila, 2009). Crop destruction by elephant impacted on both household food security and cash income. The annual crop loss is estimated to amounts to 390 tons from annual crop yields of 129,670 tons ofvarious crops (*ibid*).In trying to address the problem, the Tanzania Wildlife Research Institute in collaboration with Serengeti District Council intervened by introducing the use of chilli (pepper) in mitigating destruction of crops by elephants. The practice involves the use of grounded chilli, used engine oil, sisal ropes and mutton clothes.Ten litres of engine oil is mixed with 1.5kg of chili powder to produce an irritating mixture that is not pleasant to the targeted animal (elephant) (*Loxodonta Africana africana*) and then sisal ropes and muttonclothes are socked into the above mixture. The resulting irritating farms supported by wooden poles at an interval of 10metres apart which eventually deters elephant whose aim was to feed on crops. The length of treated rope from the above mixture usually suffices to protect an acre of crop field (SDGO report, 2014).This study therefore was initiated to assess the effectiveness of chilling methods in mitigating Human Elephant Conflicts with the objectives of identifies strengths /weakness of the method and suggest measures for improvement.

II. Study Area

Nyamburi and Bonchugu are among villages in Serengeti District. (See figure 1). Nyamburi villagelies between 34° 40" E and 1° 47" S while Bonchugu village lies between 34o45" E and1^{o} 50" S with an average altitude of 1480 m (SDC, 2014). Nyamburi has a total population of 3865 people and 787 households while Bonchugu has total population of 6114 and 579 households. The study villages are part of the high interior plateau of East Africa. It slopes to its highest part (1850 m) on the eastern plains near the Gol Mountains towards Speke Gulf (920m) along Lake Victoria. The temperature shows a relatively constant mean monthly maximum of 27^{0}-28 ^{0} C. The minimum temperature varies from 16 ^{0} C in the hot month of October-March to 13^{0}C during May-August (SDC, 2014). Rain typically falls in a bimodal pattern with the long rains during March-May and the short rains during November-December. Rainfall varies from 1200 mm in the north to 600 mm on the south-eastern plains and the Rift Valley (*ibid*).

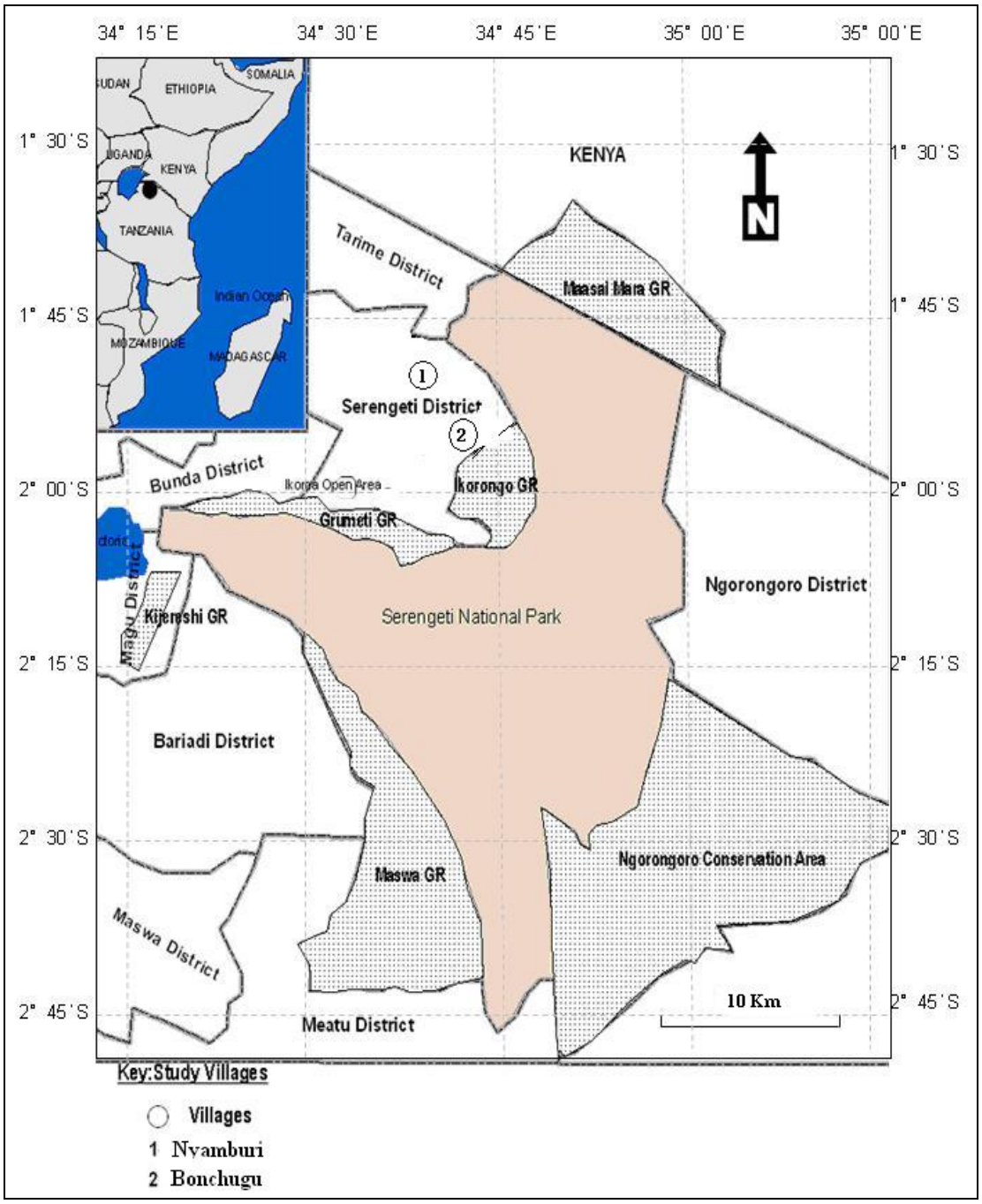

Figure 1: Map of the study area

III. Methods

Two villages (Nyamburi &Bonchugu) that are proximal to Serengeti National Park on the basis that they experienced a high level of crop damaged have been selected for the purposes of the study. A total of 82 respondents from the selected villages were randomly and purposely picked with a Sample size composition of (68) household respondents, (2) Village chairperson, (2) Village executive officer (VEO), (1) District game officer (DGO), (1) District agriculture and livestock development officer (DALDO), (2) SENAPA Ecologist, (2)Elders, (2) Youth and (2) women. Data were collected by means of questionnaires, informal interviews, and discussions with farmers. In order to understand the aspects of the issue of elephant crop raiding in the villages, farmers were asked to respond to a series of questions formulated to gather information regarding the vulnerability of various crops to elephants, the impact of crop raiding on different farming practices, the extent of crop damage incidences caused by elephants, the nature and the effectiveness of indigenous crop protection methods, and farmers' general perceptions of the elephant.Data were analysed both contently and statically. Statitical analysis was done using SPSS and excell softwares.

IV. Results And Discussion

4.1 Demographic characteristics of respondents

The socio-economic characteristics of the study area are presented in Table 1 below. Overall, in the two villages combined, the majority of the respondents were males (60%; N=68). As for age most of the respondents (68%) were between 18 and 54 years. This shows that the majority of the populations at study villages are still economically productive. Regarding social economic activities of the study villages, about 78% of the population depends on crop-based agriculture.

Table 1: Social economic characteristics of respondents

Village	N =68	Sex (%)		Age (%)			Education (%)			Socio-economic activities (%)		Household size%		
		M	F	18 -34	35 -54	>54	NF	P	S &A	A	L	1-5p	6-10p	>10p
Nyamburi	34	61	39	30	36	34	41	55	4	76	24	10	53	25
Bonchugu	34	58	42	32	38	30	38	57	5	80	20	12	50	50
Average	34	50	40.5	31	37	32	40	56	4.5	78	22	11	51.5	37.5

Keys: N =sample size M=Male F=female >=Above NF=Non Formal P=Primary
S & A =Secondary and above A= Agriculture L=Livestock p=person

The literacy level in these two villages is low as only (4.5%) have attained secondary education. This implies that, the illiteracy level in terms of formal education is high. Education is a necessary condition for social economic and technological development in any society (Author pers. Obs.).With education one can easily learn new technological advancement, adapt to change environmental conditions and learn new skills.
Regarding household size, findings reveals that, the average size of household is 8 people. The higher number of family size could probably be due to polygamy culture of the people in the area. In Mara region, particularly Serengeti and Tarime districts the culture of marrying many wives is rampant (Author, pers. Obs.). Having many wives increases the probability of having many children when compared to monogamy families and hence increased poverty level. This is in agreement by Kaswamila (2007) where he observed that income in the study area ranged between TZS 784,000 and 930,000.

4.2 Human wildlifeconflict (HWC) status

Local communities were asked to assess the current status of HWCs in their areas. Answers were limited to Yes or No. In both villages the findings reveals that, HWC is a problem (Figure 2). In Nyamburi all respondents perceived HWC a problem whereas in Bonchugu the proportion was 97%. The most destructive game being elephants (*Lexodanta Africana*), other problem animals included wild pigs (*Potamochoerusporcus*), porcupine (*Potamochoerusporcus*), vervet monkeys (*Cercopithecus aethiops*), wildebeest (*Connochaetestaurinus*), warthog (*Phacochoerusaethiopicus*) and gazelle (*Gazella grant*). The most affected crops were maize, sorghum and finger millet which are basically the main staple food in the study area. The reasons for favouring these crops could not be established. However, probably the reasons could be the nature of the crops and elephants prefer succulent crops. Results from Focus Group Discussion (FGDs) revealed that,crop damage by elephants not only affect farmer's ability to feed his or her family, but also reduces cash income and has repercussions for health, nutrition, education and ultimately, development. As farmers depends on crops for selling to obtain cash for school fees.

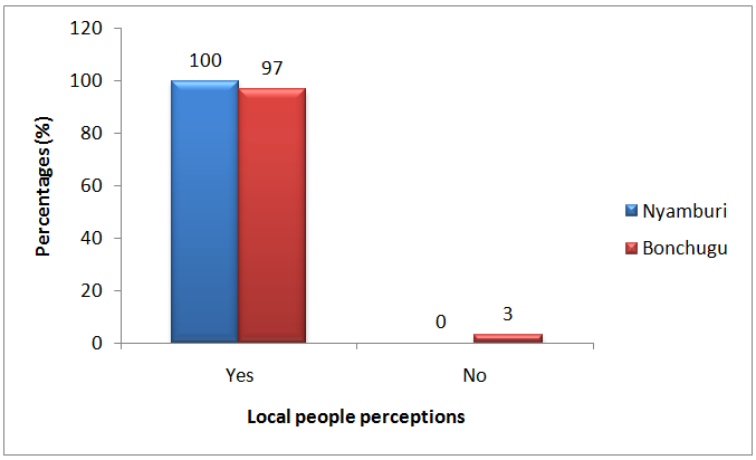

Figure 2: Local community perception on HWC status

4.3 Limitations of chill method in mitigating human-elephant conflict (HEC)

4.3.1 Types of chill and their effectiveness in mitigating human-elephant conflict (HEC)

During the study and through literature reviews it has been recognized that; different researchers tried to tackle the issue of HEC by using chill method; but no one mentioned/recommended about the variety/type of chilies to be used. This is due to the facts that, not all type of chills are hot. Chillies differ in their shape, size, color, flavour and heat either they can be hot, sweet, fruity, earthy, smoky and floral. Varieties and stages of maturity also have great influence on chillieshottness (Kanner*et al*., 2006; Sanatombi& Sharma, 2008). Scientific research has proven that, *capsicum spp*, is the only crop that produce alkaloid compound called capsaicinoids, which is responsible for the hot test. Hence pungency of chili peppers is due to the accumulation of capsaicinoids (Dorantes*et al*., 2000). The "hot" in hot peppers is due to capsaicin (8-methyl-N-vanillyl-6-nonenamide)(C18H27NO3) and not the seeds. Capsaicin is primarily found in the white membrane that holds the seeds. The stem end of the pod has glands which produce the capsaicin, which then flows down through the pod. The pain caused by capsaicin stimulates the brain to produce endorphins, which act as analgesics. Capsaicin acts on a specific nerve receptor in elephant (*Loxodonta africana africana*). Chill peppers get hotter as they ripen, a red one will be hotter than a green pepper. Also, dried peppers will always be hotter than fresh peppers, because as water evaporates from the fruit, the amount of capsaicin remaining will be of a higher concentration (Michael, 2007**).**The amount of capsaicin in hot peppers varies significantly among varieties, and is measured in Scoville heat units (SHU). SHU ratingsare not a perfectscience, as pungency values vary due to expected variation within a pepper species and growing climate.The most common species of chilli peppers are *Capsicum annuum, C. frutescens, C. chinense, C. pubescens and C. baccatum*(*Guinness World Records, 2016)*as shown in Table 1 below:

Table 1: Common Chilli pepers species and their SHU

COMMON NAME	SPECIES NAME	SCOVILLE HEAT UNITS (SHU)	SOURCES
Carolina Reaper	*Capsicum chinense*	1,569,383-2,200,000	(Guinness World Records,2016)
Trinidad moruga scorpion	*Capsicum chinense*	1,200,000 - 2,000,000	(Bannister, 2012)
7 Pot Brown (Chocolate 7 Pot)	*Capsicum chinense*	1,200,000 - 2,000,000	(Bannister, 2012)
7 Pot Primo	*Capsicum chinense*	1,473,480	(Bosland, 1996)
Komodo Dragon	*Capsicum chinense*	1,400,000	(Smithers, 2015)
Bedfordshire Super Naga	*Capsicum chinense*	900,000 - 1,120,000	(Tesco, 2012)
Carolina Cayenne	*Capsicum annuum*	100000-125000	(Herapeutic Research Faculty, 2009)
Diablo Grande Pepper	*Capsicum annuum*	60,000 - 100,000	(Schutte,2012)
Thai Pepper	*Capsicum annuum*	50,000 - 100,000	(Michael,2007)

Other chill species includes *Capsicumpubescens* maximum 250,000 SHU of its varieties, *Capsicum frutescens*maximum 100,000 SHU and *Capsicum baccatum* with maximum 50,000 SHU of its varieties.
Therefore, Carolina Reaper *(Capsicum chinense)* shows high SHU compared to other *Capsicum spp*and is favourable in tropical areas thus recommendable for mitigating human-elephant conflict (HEC).

4.3.2 Weather condition and its implication to chill method on

***In wet years chill application is a tedious work*;** during wet seasons, human elephant conflict in Western Serengeti is increasing due to the fact that; heavy rains wash away the mixture so the smearing of oil chill mixtures must be done regularly. Supply of the mixtures costs time, and needs labour power hence those people who have tried to use the method become discouraged during wet years as it works only during dry season and not a permanent solutions. Similar findings claimed by other researchers as shown in the box below:

- ✓ Chill method may not be effective as are expensive, needs labour intensive and difficulty in applications (Karidozo&Osborn,2015).Chill application was done after every two days where it becomes less firm over a period of time hence becomes sagged and add less deterrent value in mitigating human elephant conflict.
- ✓ Accordingly to Grahama&Ochieng (2008),Chill method helped a little in mitigating Human Elephant Conflict as it requires labour burden for application of chill grease on a weekly basis.
- ✓ Simon *et al.*(2010) argues that `` Chill grease fences do not add any significant deterrent effect but do add expense and create additional work".

The Table 2 below also shows the contribution of other researchers on frequency application of chill method during rainy season thus contributing to its inefficacy.

Table 2: Frequency application of chill method during rainy season

Method	Application Events	Period	References
Chilli	Daily	Higher rainfall	Govindaraj*et al.* (2007)
	After 3 days	If no rainfall	Govindaraj*et al.* (2007)
	For few weeks(Regular interval)	If no rainfall	Osborn & Anstey (2002)
	Once washed by rain	High rainfall	Chelliah*et al.* (2010)
	Every day once washed off by rain	Rainfall season	Osborn (2004)
	Weekly basis	Rainfall period	Sitati& Walpole (2006)
	Every day once washed by rain	Higher rainfall	Graham &Ochieng (2008)
	After every 2 days	Weather is in rainfall or not in rainfall period	Koridozo& Osborn (2015)
	Every day	Rainfall period	Simon *et.al*. (2010)
	Weekly basis	Rainfall period	Graham &Ochieng (2008)
	Frequently	Rainfall period	Hedges &Gunaryadi (2010)
	Every 3 weeks	Low rainfall	EPDT (2006)

Therefore as Chill pepper is more soluble in fats and oils than in water. It is recommended that; an oil as a chill binder should be applied when it is in a state of very low temperature as the oil becomes lighter as the temperature increases and gluey at low temperatures. Also, elephant chilled dung in "hutted cane" can be applied during rainy season as rain will be smashed sideways.

4.3.3 Changing behaviour of elephants against applied chill method

Elephants sometimes inter into the farms backwards; Chill mixtures produces chocking smell which is a major olfactory irritant and causes unbearable discomfort to elephant.But It was Observed during the study that, some elephants avoid eye contact with oil chilled ropes by entering the farm in a backward movemen and raids cropst.It is well known that elephants are highly scared by bee stings thus, modification of the method can be applied by combining chill and bees to scare elephants away from farms. Morover the farmers believed that; Employing many mitigation measures at once will tire the elephant hence discourage them from crop raiding.

Findings from other researches shows that, Chilling method like other modern method face the problem of elephants to overcome their fear by becoming habituated and less effective over time (Murithi, 2005). O'Connell *et al.*(2000), argues that, the greatest challenge faced by a myriad of non-lethal mitigation interventions was that they became ineffective due to habituation by wildlife species across time and space.However, modification of the method should be done by combining chill and bees to scare elephants away from farms. It is well known that elephants are highly scared by bee stings; thus, it is expected that combination of chilli and bees might be effective in stopping elephants from crop raiding.

4.3.4 Availability of oil and pepper

Insufficient used oil and pepper; even though the people leaving adjacent to Serengeti National park were attracted to use chill method in mitigating human Wildlife Conflict, insufficient used oil and pepper was among the obstacle. Some farmers were not flexible in cultivating peppers and other stakeholders such as district council, different companies and NGO'S were not supporting the provisions of used oil on time hence hinder the application of the method.

On top of that, the villagers were encouraged to plant more chill plants so as to solve the problem of chill scarcity without researched weather the soil, climate and other factors are favouringchilli pepper to growor not. Chili peppers require sunny, semi tropic or tropical conditions and annual rainfall of between 600mm and 1,250mm. A very high level of soil fertility is required for the profitable production of a successful pepper crop. The quality and quantity of pepper fruits are of crucial importance and are greatly influenced by the fertility and nutrient levels of the soil.

Pepper plants do not perform too well in very high clay soils. They rather prefer sandy to loam soils; In fact they will grow moderately well over a wide range of soil types, provided they are well drained to a depth of at least 600 mm. However certain criteria have to be satisfied in terms of the soil structure and content to make it commercially viable. These factors include; Nutrient composition, Compaction, soil depth, pH, Crop rotation, Herbicide residues and Water holding capacity. All these factors can have major influences on the resulting yield. The soil must permit adequate root growth to support the plant and supply water, oxygen and mineral nutrients and must be free of toxic elements. The rate of root growth is dependent on the degree of compaction or bulk density of the soil. The degree of soil compaction varies with soil type and location. The rate of aerial and root growth of plants increases with the oxygen contents of the soil. Root density is highest where there is a high rate of diffusion. Root development of pepper plants can be extensive if soil water and plant conditions are optimal. Early root development should be encouraged, because nearly all root growth occurs before fruit set.

Furthermore, cultivation of chill peppersshould be market oriented as a source of income in addition to sustainable application as a mitigation of HEC.

V. Conclusion and Recommendations

Generally the most thing which hinder the effectiveness of chill method in mitigating human-elephant conflict (HEC) were lack of agriculture knowledge concerning condition necessary which favour growth of different chill pepper species; behavioural habituation of elephants (*Loxodontaafricanaafricana*); lack of knowledge on effective pepper binding materials; and weather condition.

The challenges can be minimised/solved by provision of agriculture education concerning chill pepper farming to local communities to be implemented by agriculture extension officers. Usage of combination of chill method (oil/grease chilled ropes or hutted elephant dung block) and bee hives around farm plots to minimize the behavioural habituation of elephants to enter backwards.

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