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Assessment of Crop Damage and Application of Non Lethal Deterrents for Crop Protection East of the Selous Game Reserve

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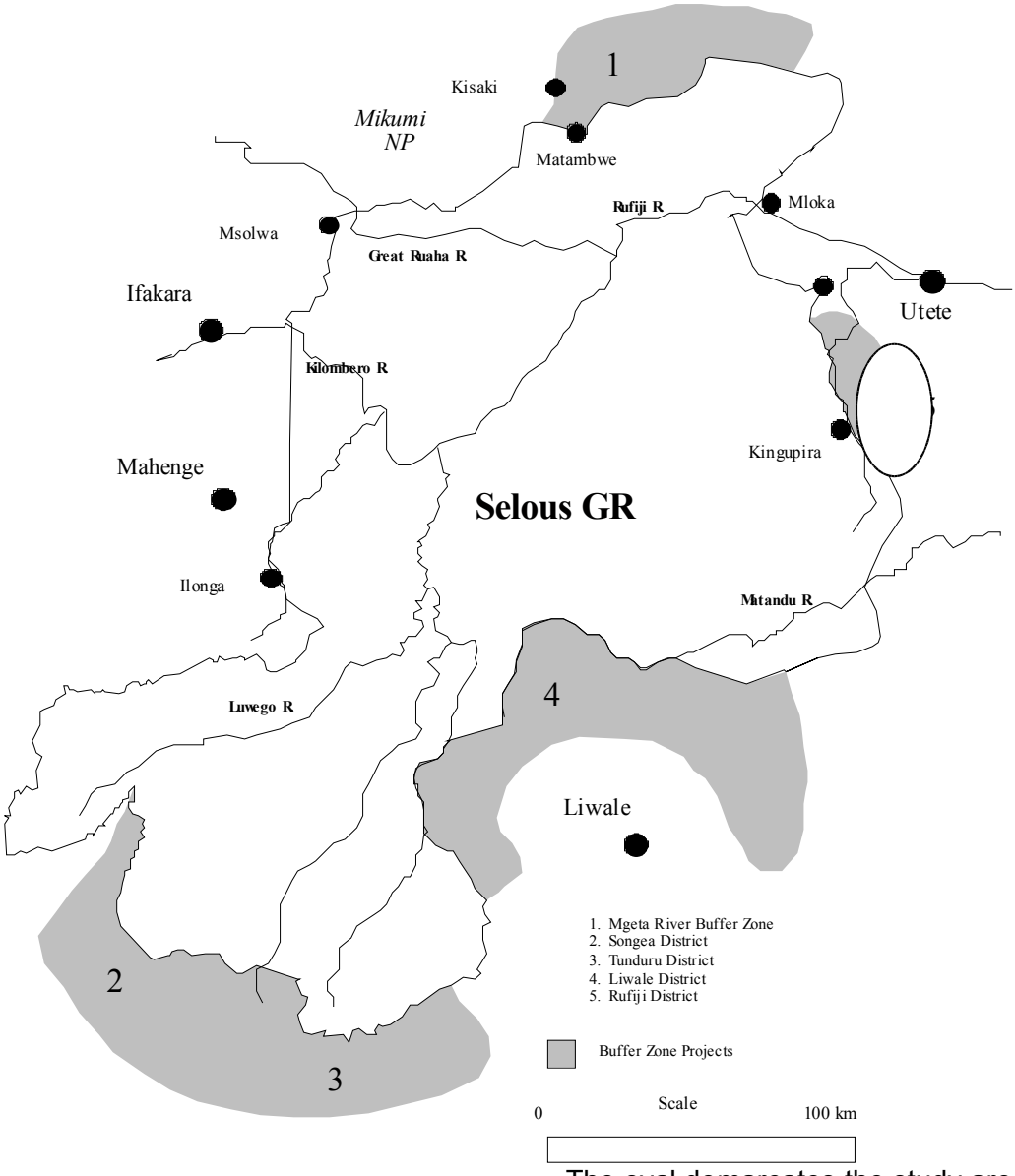

The oval demarcates the study area

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Editors Note

The research, on which this paper is based, was carried out in the communal areas adjacent to the Selous Game Reserve Sector Station Kingupira. Attached to the station is the Kingupira Wildlife Research Institute, which falls under the “research branch” of the Tanzanian Wildlife Authorities, the Serengeti Wildlife Research Institute.
Mr. Charles Masunzu, the author of this paper, is the head of the Kingupira Research Station. As the original report is voluminous and in parts very scientific, the editors have shortened it considerably and have condensed some of the information, esp. the tables. Mr. Masunzu's views and conclusions have of course remained unchanged.

As the scope of the German supported wildlife programmes has increased and new programmes have started (Saadani and Katavi/Rukwa Conservation Programmes, Advisor to Community Wildlife Management Section of the Wildlife Division), the Discussion Paper series has been renamed “Tanzania Wildlife Discussion Papers”. The numbering of the editions remain consecutive.

The Discussion Papers may contain authors’ views and positions which do not necessarily correspond with the official position of the Wildlife Division and the editors.

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SUMMARY

This study was carried out in cooperation of the Selous Conservation Programme and Kingupira Wildlife Research Centre. This final report deals with the actual assessment of crop damage and performance of harvested yields in the four study villages; information on the wild animals killed by villagers and relevant authorities in the three study districts; and the application of non lethal methods on crop protection and their effectiveness on scaring animals in four study villages namely Ngarambe and Tapika in Rufiji district and Lihenga and Namatewa in Kilwa district. Data presented here were collected within the period between January and December 1996.

The actual crop damage and performance of maize and sorghum yields were explored. Animal species responsible for killings of human beings and those killed or injured by villagers and relevant authorities within the period between 1975 and 1995 are mentioned. People killed or injured in three study districts namely Rufiji, Kilwa and Liwale are presented. Animals killed by villagers between 1985 and 1995 are also mentioned. Elephants shot on crop protection according to sex in Rufiji district between 1975 and 1979 are also mentioned.
The report evaluates both local and modern means of scaring animals. Local means comprise of shouting, throwing objects; beating objects and using fire displays. Modern include the application of combined use of blank shotgun cartridges and flares; combined use of thunder flashes and flares; and combined use of blank shotgun cartridges, thunder flashes and flares.

The responses of animals with regard to the methods used are presented. The paper also proposes the immediate implementation of appropriate non lethal methods on crop protection around the reserve. Finally recommendations on minimising crop damage and to avoid massive killings of the animals by villagers or relevant authorities are outlined.

INTRODUCTION

OBJECTIVES

The objectives of the study were:

(a) to determine the types and quantities of crops grown by the peasants and assess their production (performance of harvesting yields).

(b) to identify the wildlife species responsible for crop damage

(c) to assess crop damage and to quantify the amount of damage caused by wild animals.

(d) to identify and quantify the animals killed by villagers or relevant authorities and ascertain the validity of claims that the massive killings are truly defensive measures.

(e) to find out and to evaluate appropriate methods of crop protection and scaring wild animals without killing them.

This paper evaluates the following hypotheses, which correspond with the objectives stated above.

(i) to determine whether there is any correlation between the size of the plot cultivated and the performance of maize or sorghum yields.

(ii) to determine whether there is a significant difference between the actual performance of maize or sorghum yields and mean standard production.

(iii) to determine whether there is any correlation between the elephants shot dead or injured and the people killed or injured by elephants in Rufiji, Kilwa and Liwale districts within the period between 1975 and 1977, and 1983 and 1985.

(iv) to determine whether there is any correlation between the hippos shot dead or injured and the people killed or injured by hippos in Rufiji District within the period between 1982 - 1991.

(v) to determine whether there is any correlation between the elephants scared by local means and that scared by modern means.

The study of crop damage by wildlife and application of non lethal methods for crop protection was first initiated by N. Stronach in the period between 1990 and 1993 as part of the World Wide Fund for Nature (WWF) project on the conservation and management of elephants of the Selous Game Reserve. Assessment of crop damage was one of the research activities performed by Stronach in collaboration with the Kingupira Wildlife Research Centre in 1992/93.
This report presents the assessment of crop damage and the performance of maize and sorghum yields in the four study villages for the period between January and July 1996. It should be borne in mind that the actual damage of crops presented was based on the area of plots destroyed by animals, drought or erosion. Although the assessment on crop damage done by Stronach (1993) was on to small a scale to allow an in depth analysis, it gave indications on to which extent peasants suffer from damage from wild animals. In this study some scientific analysis has been presented.

This paper presents also the wild animals killed by villagers and relevant authorities and ascertains the validity of claims of the massive culling of crop raiding animals in Rufiji, Kilwa and Liwale districts. It also deals with the vermins (bush pig, baboon, monkeys) killed on crop protection in cooperation with both District Game Offices and District Agricultural Offices. District Game Offices deal with large game animals that endanger human life, domestic animals or crops like elephant, buffalo, hippos, crocodile, lion, hyaena and leopard, while District Agricultural Offices deal with animals that damage crops like bushpig, baboons, monkeys, rats and birds.
The expansion of human population in the study districts has led to the expansion of agricultural activities, hence reduction of the habitat requirements of many animal species in the Selous ecosystem. Stephenson (1987) pointed out that the removal of human settlements from Selous Game Reserve in 1940's following sleeping sickness, provided the opportunity for numerous species of animals, including the large herbivores like elephant and buffalo, to dominate and increase in an undisturbed environment.

The competition for resources between man and elephants is a long time problem in Tanzania. Blunt (1933) pointed out that by 1920 there were already reports of elephant problems in Uganda and Tanzania. Spinage (1973) pointed out that control programmes of elephants were initiated in Tanzania in 1920's but served only to harass the elephants rather than to exert any real control of their numbers. Up into the 80ies between 1000 and 3000 elephants were shot on crop protection every year in the south of Tanzania
In this study more than half of the total animals killed or injured by villagers and relevant authorities in the study districts were either damaging property or threatening human life. Thus animals were killed or injured on the basis of property and human life protection.

The application of non lethal methods for crop protection was introduced at the Kingupira Wildlife Research Centre by N. Stronach in 1992. However efforts of the Department of Wildlife to acquire non lethal elephant deterrents and testing them in the field started in 1989. Such efforts were necessary as the lethal forms have proved to be inefficient and had been used for a long period of time without much success. They were also often misused, that means elephants were shot under the pretext of crop protection, but in reality for their tusks. International conservation agencies were therefore requested to assist with the necessary equipment and to advise on methods for non lethal elephant deterrence.
The use of non lethal methods were emphasised in the four study villages with the highest effort at Ngarambe. This was done because Ngarambe is the only village among the study villages under a community based conservation programme. The village is growing perennial crops, and it has two growing seasons per year. The first growing season is between December and March, and the second season is between March and July. In additional to this Ngarambe is very close to the research centre and accessibility is available throughout the year.

STUDY AREA

The study area is located in the Southeast of Tanzania, east of Selous Game Reserve. The four villages studied were Ngarambe and Tapika in Rufiji district, and Lihenga and Namatewa in Kilwa district. The actual crop damage assessment and performance of maize and sorghum yields were studied in these four villages. Animal species scared by both local and modern means were intensively studied in these villages. The animals responsible for killing and injuring human beings were recorded in Rufiji, Kilwa and Liwale districts and not specifically in the 4 study villages, as there are no data available for the village level.

MATERIALS AND METHODS

(a) Assessment of crop damage

Major cultivated crop species were identified by observations. Naming of crop species was done in collaboration with Agricultural Extension Officers. Plots or cultivation fields were selected and measured by using a tape measure. Triangulation and direct measurement methods were used to estimate the size of the plot. Each village area was represented by a number of plots. Selection of plots was based on the ease of access from the research centre, feeding routes of pathways of animals and proximity from the reserve boundaries. Each selected and measured plot was numbered. The name of the plot holder was recorded. The readings on plot sizes were taken into square metres and then changed into acres (1 acre is equivalent to approximately 4,000 m^2). The types of crops growing in each plot were recorded.
The germination performance of the crops in each plot was categorised as follows:
good when the germination quantity was 75% - 100%,
medium when germination quantity was 50% - 75%,
poor when germination quantity was below 50%.
The categorisation refers to the quantity of the crop just after germination and before the damage by animals. The germination rate was estimated by using transsects. Each plot was divided into transacts. The number of seedlings that did not germinate in each transsect recorded was calculated as a loss of percentage in germination.
Animals responsible for crop damage were categorised according to the damage they caused and the time they visited cultivation fields. Direct observation was used to identify the animal species responsible for crop damage. Another method was by interviewing respondents in all study villages. Since peasants are the people who know the animal species which cause crop damage, the animal species mentioned by them were taken into consideration. Night and day visits of animals were

recorded. Torches were used at night for identification of animals that visited plots. Two people from each village accompanied the research group at night. Records of the name of the peasant, date of raiding, the crops damaged, the time animals visited the plot and the number of animals involved were maintained on forms. These forms were filled when the local contact representatives were visited in the villages.

Quantification of damage by both animals and drought or erosion were based on the area in metres damaged in of each plot.
The estimating of crop damage was done in the following way: for maize the number of plants felled or eaten by animals in each transsect were counted and the area where those plants were felled was measured by using a tape measure. The number of plants felled was equalised to the area damaged in the transsect. An average of the number of maize plants damaged in each plot was equivalent to the average total area damaged in that plot. The total area damaged by animals in the whole growing season was obtained by summing up all monthly damaged areas in all plots in each village within the period between January and May. The measurement and estimates of the crop damage done were monitored at least twice a week.
Drought and erosion affected Tapika and Ngarambe villages only, whereas drought affected all four villages studied. Estimating the damage caused by erosion was done by direct measurement where the affected area was recorded. Drought effect was measured by using transacts through counting the number of plants affected.

Estimation of sorghum raided by animals was done in the following way. The plants felled before bearing seeds were treated as damaged plants. The measuring of the area affected was done as in maize plants. Plants that were felled down by animals at matured stage through trampling were not included in the damage unless the top portion was eaten by animals. Animals like elephant feed on both the stem and the top portion of an immature sorghum. When sorghum is matured, elephants prefer to feed on the top portion and the whole plant can remain standing, if its not trampled down. In this case the estimate of damage was based on counting the plants without top portion in each transsect and treated as damage. The number of sorghum plants damaged by animals were counted and that number was equated to the total area of the plots (from the estimation of areas of all the transacts in that plot). The exercise of measuring and estimating the damage was monitored at least once a week in each village within the period between February to July.

The estimation of crop performance was done by visiting each peasant and both maize and sorghum were recorded within the period between May to July. The yields of maize and sorghum were estimated in kilograms. The total weight of maize and sorghum yields were summed up and the total recorded for each village (Table 1). The weight of mean standard yields for both maize and sorghum that were expected under normal circumstances were also calculated for each village. It should be borne in mind that mean standard production refers to an average production that the peasant expects to harvest in the absence of external forces like animals, drought, erosion etc.

The correlation coefficient r (a = 0.05) was used to test the correlation between sizes cultivated and performance of yields, and the significant difference between the actual performance of yields and expected mean products.

(b) Animals killed by villagers and relevant authorities

Each study district was visited by the researcher and data were obtained by reading monthly, quarterly and annual reports at the administration offices. Data were also obtained by interviewing different respondents. Details of manslaughter by elephants, hippos and other wild animals were obtained by reading districts annual reports and by interviewing different villagers.

The correlation coefficient v (a = 0.05) was used to test the relationship between the elephants shot dead or injured and the people killed or injured by elephants and relationship between the hippos shot dead or injured and the people killed or injured by hippos.

(c) Application of non lethal forms

The study of application of non lethal methods on scaring wild animals was intensively carried out in the whole study period in the four villages named above. Methods of scaring animals were categorised into local and modern means. Both means were used to scare animals in cultivation fields and human settlements. Local methods used include shouting; beating corrugated iron sheets, empty drums and tins; throwing gravel, soil and fire wood; and fires.
Modern methods used include: a combined use of blank shotgun cartridges and flares; combined use

of thunder flashes and flares; and combined use of blank shotgun cartridges, thunder flashes and flares.

The research group consisted of five people: The researcher who was the observer and recorder, one game scout equipped with a shotgun 12 bore that used both blanks and flares at a go but fired at an interval of seconds. The second game scout was equipped with thunder flashes, the third game scout was equipped with a .458 rifle and the fourth game scout was equipped with either a 30.06, .375 or . 404 rifle for emergencies. Within the period between January and April no thunder flashes were used. The operation time was at night. Animals particularly elephants and buffaloes were left to come close to the cultivation fields. The peasants belonging to the cultivation fields were requested to use local means in order to scare animals. Shouting; beating objects, throwing objects and use of fires were local means tested and recorded by the research group. The distance between the research group and the animal(s) was roughly estimated by direct observation at night and where possible measurements were taken by using a tape measure the following morning. The distance between the operation group and animal(s) roughly ranged between 20 - 50m depending on the location of the cultivation field and the place of the animals.

The modern method used to scare animals, particularly elephants and buffaloes was used as follows. The shotgun blank was fired at close range within the distance between 20 - 50m of the animal and the shooter. When the animal(s) had started to run away it (they) was (were) followed by the flare which scared it (them) at great deal. The thunder flash was also thrown by hand at close range within the distance between 20 - 50m of animal(s) and the thrower. Care was taken enough to avoid the animal(s) to attack or to run towards the research group. Wind direction and darkness were factors put into consideration.
The thunder flash was used as follows: The thunder flash's cap was removed and the thunder flash lit and within the five to ten seconds burning lag, it exploded with a loud bang that scared animal(s). This thunder flash was also followed by the use of a flare. The loud bang from the thunder flash scared the animal(s) and when the animal(s) had started to run away it (they) was (were) followed by the flare in order to increase the psychological effect. The third method consisted of using shotgun blank and thunder flash at different regular intervals. This again was followed by the use of flare.

The response of animal(s) was categorised and recorded into three groups:
- positive response,
- slightly positive response
- negative response (no response at all)

The response categorisation was used in both local and modern methods. Species, total animals and type of the method used to scare animal(s) were recorded on the tabulated sheet forms. The research group operated two - three nights per week depending on the reported information from the villagers. Each village was represented by one peasant who recorded every animal visiting the cultivation fields in the absence of the research group. All animals scared by both local and modern means in each month were recorded. The number of shotgun blanks, thunder flashes and flares used to scare animals in each month were also recorded.

RESULTS

(a) Assessment of crop damage

Cultivated crops in the study area can be categorised into three main groups namely annual, semi perennial and perennial crops.
Annual cultivated plant species include the major crops seasonally grown in the study area. These are; maize (Zea mays); sorghum (Sorghum vulgare) and rice (Oryza sativa).
Semi perennial cultivated plant species include cassava (Manihot esculenta), banana (Musa cavendishii, Musa esente and Musa sp) and sugar cane (Saccharum officinarum)
Perennial cultivated plant species include cashewnut (Anacardium ocidentale) and coconut (Cocos nucifera).

Other minor cultivated plant species are groundnuts (Arachis hypogea), Pigeon beans (Cajanus cajan), melon (Cucurbita mero), and simsim (Sesamum sp).
Cultivated plant species which include fruits are pawpaw (Carica papaya), mango (Mangifera indica) and Orange (Citrus sp). It should be borne in mind that perennial and semi perennial crops are grown on small scale level.

Animal species responsible for crop damage in the study area were categorised into three main groups as follows:

(a) those animal species that damage crops during the day. These include yellow baboon (Papio cynocephalus), Vervet monkey (Cercopithecus aethiops arenarius) and Rufiji blue monkey (Cercopithecus mitis monoldes).

(b) those animals species that damage crops at night. These include African elephant (Loxodonta africana), bushpig (Potamochoerus porcus), hippopotamus (Hippopotamus amphibius) and buffalo (Syncerus caffer).

(c) those animals species that cause minor damage of crops at night. These include warthog (Phacochoerus aethiopicus), eland (Taurotragus oryx), greater kudu (Strepsiceros strepsiceros), bushbuck (Tragelaphus scriptus), impala (Aepyceros melampus), black backed jackal (Canis mesomelas), Reed buck (Redunca redunca), porcupine (Hytrix africae astralis) and cane rat (Thyronomys swinderianus).

Regardless of categorisation, the animals that damage crops to the greater extent are elephant, buffalo, bushpig, baboon and monkeys. Rats were reported by many respondents that they cause great damage on stored cereal crops at home.

Damage to crops varied from one village to another and from one plot to another within the study area. The more a peasant guards and attends his/her field, the less the crop is raided by animals. Under good weather, those peasants who attend their plots by frequently weeding and guarding, obviously obtained higher yields than those who don't weed or guard. The peasant has to guard against animals all the nights and days in the growing season if she/he wants to obtain high yields. Elephant, bushpig and baboon are animals that cause greater damage both in wet and dry season, while buffalo is reported and recorded to cause great damage in the early dry season. Baboons start to destroy maize seedling immediately after germination. They poke germinated maize seedlings and continue to damage crops in the cultivation until harvested. Elephant and buffalo start to feed on maize seedlings between 3 - 4 weeks after germination. They also continue to damage until the crop is harvested. However buffalo was reported to cause minor damage when maize seeds were mature and dry for harvesting. Bushpigs were reported to use stems of maize and sorghum at early stage.
The relative ranking of damage caused by elephant varies in the study area. With exception of Lihenga, the rest of the villages suffered heavily from crop raiding by elephant and buffalo. Bushpig was reported, observed and recorded every night in the fields within the whole period of assessment between February - July. However it was difficult to assess the damage caused by this particular species due to limited time and manpower in the field. It was, however, noted that the major culprits in incidents of crop damage were bushpig and elephant.

Elephants were found to enter crops most in both wet and dry season depending on the location of the field from the feeding routes or direction of reserve. For example, at Ngarambe, those plots located around the Lung'onya seasonally flooded swampy area, suffered lightly from crop raiding by elephants in the intensive wet season particularly between March and May. At Tapika, with the highest rainfall between March and May, crop raiding by elephants peaked in this period.
When crops are harvested, the number of elephants raiding other minor crops was increasing at Ngarambe, Tapika and Namatewa villages.

Results indicate that maize and sorghum are heavily affected by both animals and other factors like drought and erosion. Animals accounted for at least 15.2% of maize damage and at least 20.5% of sorghum damage. Drought and erosion accounted for at least 12.1% of maize damage and at least 15.8% of sorghum. It should be borne in mind that erosion did not affect Namatema and Lihenga villages (Table 2). However drought contributed to poor harvesting of maize and sorghum in these villages.

RELATIVE DAMAGE RATES, YIELDS AND EXPECTED MEAN STANDARD PRODUCTION FOR SORGHUM FOR THE PERIOD OF BETWEEN JANUARY TO JULY 1996.

NAME OF THE VILLAGE	TOTAL ACRES PLANTED AND ASSESSED	TOTAL ACRES DAMAGED BY ANIMALS	TOTAL ACRES DAMAGED BY DROUGHT AND EROSION	YIELDS OF SORGHUM IN KILOGRAMS	EXPECTED STANDARD MEAN PRODUCTION ACRE PER KG	GERMINATION QUANTI-TY IN%
NAMATEMA	47.6	11.6	5.7	3,075 KG	11,424 KG	80
LIHENGA	44.2	7.2	8.8	2,850 KG	11,424 KG	85
TOTAL	91.8	18.8	14.5	5,925 KG	22,032 KG	AV. 77.5

Table 1.

RELATIVE DAMAGE RATES, GERMINATION QUANTITIES, YIELDS AND EXPECTED MEANS STANDARD PRODUCTION OF MAIZE WITHIN THE PERIOD OF BETWEEN JANUARY - JULY 1996

NAME OF THE VILLAGE	TOTAL ACRES PLANTED	TOTAL ACRES DAMAGED BY ANIMALS	TOTAL ACRES DAMAGED BY DROUGHT AND EROSION	YIELDS OF MAIZE IN KILOGRAMS	EXPECTED STANDARD MEAN PRODUCTIONACRE KG	GERMINATION QUANTI-TY IN%
NGARAMBE	42.8	5.6	3.4	2,500 KG	30,816 KG	75
TAPIKA	50.7	8.1	4.6	3,700 KG	36,504 KG	70
NAMATEMA	47.6	7.9	5.7	2,850 KG	34,272 KG	80
LIHENGA	44.2	6.6	8.8	2,700 KG	31,824 KG	85
TOTAL	185.3	28.2	22.5	11,750 KG	133,824 KG	AV. 77.5

Table 2

(b) Animals killed by villagers and authorities

Animal species killed or injured by villagers and relevant authorities (District Game Offices and District Agricultural Offices) can be grouped into two main groups.
First, those species that were killed or injured during crop protection. This group includes African elephant, buffalo, hippopotamus, bushpig, yellow baboon, vervet monkey, warthog and rats;
second those species that were killed or injured during domestic animals and human life protection. This group includes lion, leopard, crocodile, and spotted hyaena.
Some animal species are found in both groups as they cause crop damage and loss of human life.

The number of animals killed or injured differs from one district to another. Rufiji has the highest number of animals killed or injured within the period between 1975 - 1995 (Table 3). This number includes the hippos and crocodiles that were killed under the cropping project. On the other hand Liwale district has the highest number of elephants killed during crop protection within the same period (Table 3). Kilwa was the second district in the number of elephants killed during crop protection operations within the same period (Table 3). Many elephants were injured in Rufiji district (Table 3). On the other hand the highest number of people killed or injured by wild animals in the study districts was found in Rufiji district. More than 3000 elephants were shot in Liwale within the period of 21 years. In Kilwa more than 2000 were shot and about 1700 elephants were killed in Rufiji district.

Many people were killed or injured by hippopotami (Table 3). More than 100 people were killed and 80 people injured by hippos within this period in all three study districts. Rufiji has the highest number of people killed or injured by hippos. Rufiji district has also the highest number of people killed or injured by crocodiles. To reduce the number of hippos and crocodiles in Rufiji district, cropping was introduced. Hambo Enterprise Company and Tumaini Enterprise Company were issued to crop these animals. In 1991 more than 130 hippos were cropped by Hambo Enterprise Company in Rufiji district (Table 8). In 1987 M/S Tumaini Craft Company killed more than 200 crocodiles in Rufiji district. Rufiji has the highest number of hippos and crocodiles killed within the period between 1983 - 1985, and 1987 - 1991 due to the cropping scheme

Vermin animals were killed in crop protection with cooperation of District Game Offices, District Agricultural Offices and Villagers (organised hunting groups). About 5000 bushpigs, more than 4000 baboons and about 4000 monkeys were killed by the villagers and the relevant authorities in Rufiji district (Table 4).
About 30,000 vermins were killed on crop protection in the study districts within the period between 1985 - 1995. Rufiji was the only study district which recorded rats as vermins. About 120,000 rats were killed in crop protection by using Zinc phosphide within the period between 1985 - 1995

Many respondents complained that the Selous Game Reserve had brought a lot of problems to the local people living adjacent to the reserve. They mentioned the crop damage and loss of relatives as the most and prevalent widespread problems.
Records obtained did show that the majority of people killed by animals were adult men, with relatively few victims being adult women and children. Most of the victims were killed in the proximity of wildlife habitats, cultivation fields or in residential areas.
The number of people killed or injured by animals included peasants, fishermen, water fetchers, firewood collectors, basket materials collectors, building material collectors and people who were bathing or washing clothes in rivers. It can be safely assumed that a number of these were actually poaching. The frequency of contact between men and animals were higher than with women and children. According to the records and respondents in this study, about 90% of the victims killed by elephants were adult men. This is corroborated by Sukumar (1989), who has pointed out that in Southern India the majority of the people killed by elephants are adult men who are about 77% of the victims. It is not to farfetched to assume that wounding of animals on crop protection shooting is contributing to the death rate.

Many encounters between people and wild animals took place in the wildlife habitats. It is estimated that about 70% of encounters between people and wild animals occurred in wildlife habitat and 30% within settlements. It was noted from the respondents that people walking along path ways or roads going to their cultivation fields, shops medical treatments, schools etc. in the wildlife habitat are at risk. The respondents said that encounters within settlements were almost invariably at night.
Elephants were reported to have killed people by demolishing their platforms in the fields(dungu).
Many elephants were shot in crop protection between 1975 - 1977 and 1983 - 1985. Under statistical analysis, data recorded show that there was a negative correlation between the elephants killed or injured and the people killed or injured by elephants within these two periods ($r = 0.771$, $p > 0.05$).

Many elephants shot were bulls. It was noted that bull elephants are usually the most tenacious raiders. The bull elephants respond more aggressively to any attempt to chase them away from the shambas. It was noted further that a flash light shone at bull elephants often evokes a charge and the animals attempt to follow the position or direction from where the light was flashed. A good example was noted at Namatewa village where the bull elephant attempted to pull down the platform (dungu) where the burning torch was left.
An attempt to record the sex of elephants killed was done in Rufiji district between 1975 - 1979 but only a few individuals were recorded (Table 14). According to these data, the difference between the number of bull elephants and females shot was highly significant ($x^2 = 223.98$, $p << 0.001$). Not only adult elephants were shot within this period, even calves were included in the incidents. Abnormal elephants such as single tusk and tuskless were also recorded in Rufiji within the period 1975 - 1979. Tuskless elephants were probably included in the number of calves.

Liwale district killed about 45% of the total elephants shot in crop protection within this period. For obvious reasons, Rufiji district killed or injured about 75% of the total hippos within the same period. Rufiji killed 98.2% of the total crocodiles against domestic animals and human life protection. The district contains large rivers and lakes. On the other hand Rufiji had the highest number of people killed by crocodiles. Under statistical analysis, there was a negative correlation between the number of people killed or injured by crocodiles and the number of crocodiles killed or injured against domestic animals and human life protection within the period between 1986 - 1995 in Rufiji district ($r = 0.566$, $0.10 < p < 0.20$). Crocodiles killed or injured many women in Rufiji district when they were fetching water along Rufiji river. To reduce the losses by crocodiles, in some villages men decided to make a fence for women to fetch water safely.

(c) Application of non lethal deterrents

Results indicate that self defence by peasants on against crop damage by wild animals largely depends on scaring these animals. Those cultivators who were careful enough to use self defence measures (local means) guarding their cultivation at night and day, noted less damage and higher yields than others (Masunzu 1996a). Local means however seem to be more effective in scaring small animals such as bushpigs, baboons and monkeys rather than against large game animals like elephants and buffaloes. It was noted that large game animals such as elephants and buffaloes were reluctant to move and frequently charged when scared by local methods. When scared by local means these animals were sometimes shifting from one cultivation field to the next one. The responses of these animals as noted were positive but a few of them slightly positive and negative.

However the number of animals that responded slightly positive and that did not respond to the use of local means was positively correlated ($r = 0.814$, $df = 10$, $0.001 < p < 0.002$). More elephants visited cultivation fields during the study period as compared to other animals. It was noted that many peasants attempted shouting, beating objects, throwing objects and fires to scare bushpigs, buffaloes and elephants. Buffaloes and elephants were found to ignore fire displays and shouting in such that they continued their feeding. Each peasant has a platform (dungu) where keeping guard at night was done. Many peasants claimed that they feel more at ease to scare elephants at night than buffaloes. Scaring buffalo(es) by using local means was found more risky than scaring elephant(s). Elephants and buffaloes were found to avoid to visit cultivation fields when there was much wind.

In additional to these local means of scaring animals, physical barriers were noted to be used in the past two years at Ngarambe and Lihenga villages. Fencing was made to prevent bushpigs from entering into cultivation fields. The fences were noted to be ineffective in keeping away large animals like elephants and buffaloes.
The use of modern means started in late January. Within the period between January and April, the use of combined shotgun blanks and flares was the only modern means applied. The use of combined thunder flashes and flares started in May. Within the period between January and June, two to three nights operations were sufficient to scare elephants from cultivation fields for at least one week. Within the period between July and September two nights operations were sufficient to scare elephants. However the number of elephants visited the cultivation fields increased in September. Within the period between October and December number of elephants visiting cultivation fields and settlements increased, particularly at the end of this study. Two to three nights operations were sufficient to scare the elephants from both the cultivation fields and human settlements for at least three days. Following the drought in the reserve, the number of elephants visiting cultivation fields and settlements increased in December. Hence three nights operations were insufficient to scare the large number of elephants that visited settlements and animals were scared away for at least two to three

days only. However the number of elephants that showed positive response to local means increased.

It was noted that when elephant(s) was (were) scared by using shotgun blanks, followed by flares, they ran away to a distance between 100 - 200 m then stopped and listened. On the other hand when the shotgun blank was fired without followed by the flare, the animal(s) run away to the distance between 50 - 100 m, where they stopped. It was noted further that when shotgun blank and thunderflash were used at regular intervals, followed by the flare, elephants estimated to run away to the distance between 200 - 300 m. The distance covered however depended on the direction of animals' routes towards the cultivation fields or settlements. When animals were scared and ran away on the different normal routes, the distance covered by the animals was reduced and vice versa.

The use of thunderflashes and flares combined was noted to be more effective against buffaloes than elephants. On the other hand the use of combined shotgun blanks and flares was more effective against elephants than against buffaloes. The shotgun blank was noted to produce a louder bang than thunder flashes. Thunder flashes were found to be easy to use but unfit in wet conditions. Being like a match box, thunder flashes do not strike to light when wet.
The application of the combined use of shotgun blanks and thunder flashes at regular intervals, followed by flares, was the most effective strategy against elephants and buffaloes. There was one incident where this combination of devices failed to scare one particular bull buffalo. In June, the research group encountered a group of four buffaloes including a bull in the cultivation field of maize at Ngarambe. The bull buffalo did not respond when both local and modern means were used. Six attempts were made to scare this bull buffalo but instead of running away, the animal charged and followed the operation group. The animal was shot by the Game scout. Since Ngarambe Village is under the community based conservation programme, the dead animal was given to the villagers. Meat was sold to the villagers and about 65,000 Tshs. (about US $180) was collected and the money helped to boost the village's Bank Account.

Stronach (1993) pointed out that breeding herds of elephants are the most easily scared and stayed away for at least two weeks when combined shotgun blanks and flares were applied. In this study it was found that breeding herds were more aggressive than non breeding herds and that when scared, the herds stayed away for at least one week. It was noted that bull elephants were frequently encountered feeding solitary in the cultivation fields and it was found to be easier to drive away solitary elephants from cultivation fields by modern means than breeding herds. However to drive away solitary bull elephants by local means was more difficult. The solitary elephant was frequently found to charge when local means were applied. The combination of shotgun blanks, thunderflashes and flares scared the animal a great deal. Both local and modern non lethal means were noted to be effective against most species. The relationship between local means and modern means on scaring elephants can be demonstrated ($r = 0.970$, $df = 10$, $p < 0.001$).

DISCUSSION

(a) Assessment of crop damage

Major crops grown in the study area are maize, rice and millet (finger millet and sorghum). These crops are heavily affected by elephant, buffalo, bushpig and baboon raidings. Two types of damage have been noted: first the damage caused by vermin animals such as bushpigs, monkeys and baboons which is widespread and continue throughout the cropping cycle,
second the damage caused by larger game animals such as elephant, buffalo and hippopotamus. Crop damage caused by animals have discouraged peasants to expand their cultivation fields. This has led to the deterioration of the standard of living of the Wangindo people living adjacent to Eastern Selous ecosystem. Rodgers (1976) has pointed out that organised crop protection mainly from Elephant started in the 1930's with the provision of a Game scout called Mohammed Nkanje permanently stationed at Lukuliro in the Eastern Selous Game Reserve. From what Rodgers (1976) gathered, Game scouts were probably killing around fifty elephants per year in the early 1940's. Stephenson (1987) has pointed out that from the figures of numbers of elephants shot for cultivation in the Southern Province that the population in the Selous which harboured the marauders, substantially increased during the early 1930's (Table 15). An average of about 900 elephants were shot per year due to crop protection within the period between 1931 and 1935 in the Northeast, East, Southeast, South and Southwest of Selous ecosystem. This indicates that the Colonial Government had the

intention to address the problem of elephant raidings in Selous ecosystem.
The shooting of animals on crop protection in Selous ecosystem is likely to continue if no immediate actions are taken. Crop damage is a wide spread problem that has a significant negative impact on rural people's standard of living.
The Wangindo people live in an inhospitable environment that has a long drought period, poor soils, uncertain water supplies in some villages and incidence of crop damage by animals. Tradition and famine had led to the utilisation of a variety of natural vegetation and many natural fruits. Crosse-Upcott (1958) quoted by Rodgers (1976) that Wangindo people have a considerable knowledge of natural vegetation and many fruits, leaves, roots, mushrooms and animals were utilised, even to the extent of gathering grass seeds for grinding into porridge. Being hunters these people do not utilise some animal species. Wangindo people do not eat striped animals such as zebra, eland, kudu or bushbuck as they believe they may be infected with leprosy. Vermin animals such as monkeys and baboons are also not eaten by these people. Rogers (1976) pointed out that prior to the spread of Islam, most game species but not elephant, were eaten and at times of famine even rats and insects. Religion later prevented eating of pig and hippo meat.

Animal populations are increasing and at the same time human populations expand year after year. The human population expansion has led to the expansion of agricultural activities which limit the wildlife habitats. Thus there is competition for resources between the wildlife and human population around the reserve. To resolve the conflict between the use of wildlife resources by rural populations on one hand, and the interests of conservation in protected areas on the other hand is of course a key question to conservation world wide and very difficult to answer (Bell 1984)
The Wangindo agricultural system has shifting cultivation character. The shifting cultivation has led to poor utilisation of the land along the Selous ecosystem. In other words shifting cultivation has led to the isolating of human settlements and isolated cultivation fields in some areas. This has influenced the intensity of crop raidings within the study area. Bell (1984) pointed out that competition between humans and wildlife for resources is a basic feature of mans' relationship within his environment. Field (1976) emphasised the importance of clumped settlement patterns as a primary means of defence against wild animals. Because humans have selected their food crops primarily on considerations of sensory quality, digestibility, absence of toxins, productivity and in recent times, for their nutritive value, is not surprising that many such crops are also attractive to wild animals, especially if these crops are analogous to their wild counterparts (Sukumar 1989). A main factor that influences the decision to consume or reject a plant is its palatability as conveyed to the herbivore through the sense of taste, smell, sight and touch (Sukumar 1989). Ungulates show a positive selection of plant species and plant parts with the highest protein value (Field 1976) or minerals such as sodium (Belovsky 1981). From these views one can conclude that wild animals have to raid crops in order to supplement their insufficient food contents which they obtain in normal habitats. The people living adjacent to protected wildlife areas will continue to have to combat crop damage from wild animals. Coexistence of wildlife and people along the reserve will be more positive with proper land use planning. Funds fur social services such as water, schools, dispensaries, transport etc can be generated if people are involved in community based conservation.

The total loss of acres damaged by animals for both maize and sorghum in the four study villages estimated to be 20,304/= and 4,512 kg respectively.
The loss incurred by each family averages 22,560 Tshs. for maize and 41,081.18 Tshs. for sorghum. It should be borne in mind that the loss caused by other factors such as drought and erosion are not considered here. In addition to these losses the peasants spent money on crop protection to purchase kerosene for lamps and batteries (dry cells) for torches.
A certain number of manhours are lost because peasants are forced to guard their fields at night and during the day. The whole family has to participate in attending and guarding the field. Children have to guard cultivation fields during the day instead of going to school. Even those children who attend school sometimes have to walk long distances in a day because the whole family shifts to the cultivated fields which is far from their permanent residential areas. Each family has to build a small hut or platform (dungu) that is used for guarding animals particularly at night. The peasants have to keep the family members at the temporary huts rather than allowing them to attend school or find other jobs. The results have indicated that the crop production from the cultivation fields do not allow to keep each family financially well. This has led to famine and deterioration of the standard of living. If one considers time in terms of hours and payments per hour, the loss is as follows: assume each peasant spends 10 hours per night during 150 nights keeping watch for elephant and bushpig in the sorghum field, this would amount to 1500 man hours lost. If the payment is 50 Tshs per hour, the opportunity costs for the labour is 75,000 Tshs. If on top of that each cultivator spent 10 hours per day during 150 days keeping a watch for baboons, monkeys and birds, this would amount to 1500 man hours lost. Again the wage potential of this time period is 75,000 Tshs. Thus the total opportunity

costs for this period is 150,000 Tshs per peasant which is about US $250 in a six months period. Hence the total loss in terms of crops and time is estimated to be 170,000 to 175,000 Tshs. for a maize cultivator and 190,000 to 200,000 Tshs. for a sorghum cultivator. The above calculations are somewhat hypothetical, because often there are no opportunities to earn wages in the 4 study villages, but they give an indication of the potential magnitude of the problem.

(b) Animals killed by villagers and relevant authorities

When wild animals (herbivores and carnivores) damage people's shambas, domestic livestock or people themselves, they create a powerful social and economic justification for their elimination. Bell (1984) classified damage causing species into two major groups as follows.

- Those species that require a large wilderness refuge such as a conservation area for survival and which cause damage on brief visits to settled areas. This group includes elephant, buffalo and lion.
- Those species that can survive in small wilderness patches within settled areas without a large wilderness refuge, this group includes bushpigs, baboons, monkeys, leopards, crocodiles and hippos as well as most small mammals, birds, reptiles and insects.

Many people have lost their lives through these animals within the study period. It should be borne in mind however that not all incidents of people killed by wild animals are reported. The data collected here are therefore probably by no means complete. An average of 18 people killed per year within the period of 21 years in three districts is probably a considerable under-estimation. In the same time about 13 people were reported to be injured by animals. Many death incidents of people caused by wild animals were inevitable because the frequency of encounters between people and wild animals took place in the wildlife habitats and within human settlements, but it can be assumed that a high percentage happened on poaching trips.
People will continue to loose their life unless immediately action is taken by the relevant wildlife authorities. The cropping of crocodiles and hippos done in Rufiji district in 1987 and 1991 respectively was one of the measures to reduce the populations.
The Rufiji river with 12 tributaries emptying water in it, accommodates the largest number of crocodiles and hippos in the country. Many death incidents in the study districts were caused by hippos and crocodiles (Table 7). Thus the culling of crocodiles done under the cropping scheme described above was the right solution in order to reduce the population. An average of 4 people killed by crocodiles per year within the period between 1975 - 1995 was recorded, but the actual figure is certainly much higher. The cropping of hippos and crocodiles should continue at regular intervals in order to reduce their populations.

(c) Application of non lethal deterrents

It seems that people living adjacent to Selous ecosystem largely depend on local means of keeping animals out of cultivation fields and human settlements. Modern means such as the use of shotgun blanks, thunderflashes and flares combined have not been used in most of the villages. Local methods used to harass elephants in cultivation fields are risky. Although local means are less effective against large animals like elephants and buffaloes, these methods play a great role against vermin animals such as bushpigs, baboons and monkeys.
A considerable share of elephants and buffaloes however responded positively when scared by local methods. This indicates that local methods help to reduce impact of animals feeding in cultivation fields and human settlements. Among 1090 elephants scared by local means 81% responded positively, 11.5% slightly positive and 7.5% did not respond at all. For buffaloes 77% responded positively, 18% slightly positive and 5% did not respond at all. Finally for bushpigs 95.2% responded positively, 4.8% slightly positive and no animal did not respond. For modern means, among 692 elephants scared 95.7% responded positively, 3.3% slightly positive and 1% did not respond at all. For buffaloes 90% responded positively, 6% slightly positive and 4% did not respond at all. For bushpigs all responded positively. Thus a large number of animals positively responded to modern means.

Fencing for bushpigs had been tried at Ngarambe and Lihenga Primary School but ended in failure.

Bell (1984) pointed out that convectional fencing has been used particularly in South Africa, an early example being the elephant proof fence at Addo National Park, followed by the elephant - proof fence on the eastern boundary of Kruger National Park. Fences were constructed of railway rails imbedded

in concrete.
A combination of fence and ditch had been tried in Kenya. The construction of a ditch immediately inside the fence prevents elephants access since elephants cannot negotiate a steep-side ditch. This however is very expensive and peasants cannot afford it unless given support from the government. A trial of conventional fence with steel up rights and high tensile wire was carried out in Meru National Park in Kenya in 1979 but was reported to end in failure. Sukumar (1989) pointed out that trenches have been used for a long time in Southern India to deter elephants in cultivation fields but largely proved ineffective in keeping away elephants. Sukumar (1989) proposed a trench to be at least 2m deep, 2m across at the top and 1.5m across at the base in order to effectively prevent elephants from crossing over. Trenches or ditches have a high rate of failure particularly in wet conditions when soil is soft, as elephants have a tendency to dig the soil with their fore feet, fill up the trench and get across (Sukumar 1989).
Bell (1984) pointed out that conventional fencing is effective against most species except elephants and that no conventional fence yet designed has been fully effective with elephants. All conventional fences are extremely expensive to install and maintain and are scarcely appropriate to large African conservation areas with tight budgets and poor access. It is impossible for peasants to deal with conventional fences against elephants without support from the government.

Numerous experiments with elephant in Africa and Malaysia have shown that electric fencing is generally effective (Sukumar 1989). In Malaysia electric fencing was done around oil palm and rubber plantations and a success rate of 80% was reported (Sukumar 1989). It has been reported however that elephants may learn the weakness of the fence. For example one bull elephant has been reported to break through the fence in Kemasul, Malaysia, by rearing up on its hind legs, placing its front foot on the upper wire as the sole of the foot is a bad conductor. On the other hand a bull elephant may try to use its tusks which is also non conductor, to break the wire or prise an insulator loose. Sukumar (1989) has concluded that the electrical fence is not a physical barrier but merely a psychological one. Bell (1984) has concluded that control measures like electric fencing can be rated cost effective only when the value of damage prevented exceeds the cost of protection over the fence's life, and that crops are usually more dispersed and of lower unit value so that value does not justify the control measure in simple cash terms. This is exactly the situation in the study villages.
There are other potential possibilities to protect crops such as:
the creation of wide buffer zones which lack any cover between cultivation and natural habitat, discourages elephants from using these areas and hence avoid elephant contact with cultivation (Seidensticker 1984). On the other hand elephants tend to learn the source of water by smelling and the palatability of cultivated crops, so they will cross the open spaces after getting used to them..
Piesse (1982) proposed the use of high frequency sound beepers along with an electric fence may have potential in repelling elephants.
Sukumar (1989) has proposed the spraying of chemicals which may repel elephants but so far no chemical has been proved effective and chemicals may not persist in the environment under wet conditions.

The use of lethal forms for crop protection in East Africa, has been used since 1930's without much success. Bell (1979) has suggested that control shooting may have to be substituted by some other form of controlled off-take, and overpopulation may mean that the population may increase towards or beyond ecological capacity, or that an equivalent off take in some other form may be allowed, either by tolerating a higher level of illegal off take, or some form of culling or licensed hunting programme. Stronach (1993) has suggested that crop protection shooting could be incorporated into the existing and future village wildlife schemes and he proposed that the shooting on crop protection should be sold to the clients who are ready to hunt non trophy animals. This might develop a balance between damage suffered and benefit derived.

Rodgers (1978) has reviewed the levels, impact and efficiency of control shooting of elephants in Tanzania from 1920 to 1976. His basic recommendations for the South East of the country were;

(a) Elephants should be eradicated from those areas far removed from the main conservation areas (Viz. Selous Game Reserve and Mikumi National Park) where they are a threat to cultivation

(b) Control shooting will necessarily continue around the periphery of Selous Game. Reserve and Mikumi National Park and should be organised to produce
  (i) a financial return from the products and
  (ii) Scientific data on the nature and effects of controlling elephants both in terms of the elephants themselves and of the people's crops.

(c) As a pre-requisite to both the above approaches, scout training for control work and supervision in the field by senior staff should be reintroduced.

Stronach (1993) pointed out that disturbance shooting of animals in breeding herds combined with non lethal methods of scaring the elephants is better strategy and that if the breeding herds move away from the cultivation many of the young bulls are likely to follow. However Stronach (1993) proposed the control shooting regulations should incorporate the following guidelines:

(a) elephants should be shot within the area of cultivation and not beyond 300 metres of the edge of cultivation,

(b) those parts of the elephant which are not recovered (bones, skin, meat, guts etc) should be distributed around the margins of the shambas. They should be hung from trees to prevent their being carried off by hyaenas,

(c) Where the safety of the client's permits shooting would have to take place at night, the elephant to be shot should be a member of a breeding herd.

One solution of the problem of crop protection from large game animals like elephants and buffaloes can be the preparation and application of proper land use and wildlife management practises. Most human settlements around game protected areas are randomly arranged in such a manner that scaring animals like elephants and buffaloes is difficult.
Following the operation Uhai in Tanzania in 1989, the removal of the warn-off-effect of ivory poaching has also tended to encourage elephants to move more freely and to loose their fear of humans.

The use of non lethal deterrents can be effective if rural people around the reserve are involved in the conservation and sustainable utilisation of wildlife resources. Involvement of local people in wildlife conservation is inevitable if the Government wants to apply non lethal methods on crop protection. The district game offices nowadays do not have the resources to post game scouts in relevant villages. Community Based Conservation will help to protect natural resources, to manage the resources on a sustainable basis, to strengthen the regulations concerning utilisation of wildlife and facilitate the development of rural areas around the reserve. Phillips (1992) pointed out that protected areas cannot survive unless those who plan and manage them recognise the needs of human populations especially those who live in such areas. Protected areas cannot survive solely through the efforts of governments, non governmental bodies and the owners of private lands have an important part to play too (Phillips 1992).

The application of the combined use of shot gun blanks and flares, combined use of thunder flashes and flares, and combined use of shotgun blanks, thunder flashes and flares is sufficient to scare the majority of large game animals particularly elephants, buffaloes and hippos. In this study the use of modern means two to three times per week in the four study villages were effective. Two to three nights operations were sufficient to scare elephants for at least one week in the period between January and June; and for at least two - three days in December. Thus the application of modern means seem to be effective if a continuous operation is done. The village Game Scouts who are stationed in each village can operate this manoeuvre smoothly.

CONCLUSION AND SUMMARY OF RECOMMENDATIONS

- The Community Based Conservation Programme where local people are involved in the process of natural resource management and benefit through the sustainable utilisation of resources, should be emphasised with a view of integrating the local people in crop protection.

- Intensive study of early warning mechanisms on distribution and seasonal movements of wild animals around settlements and farms should be carried out.

- Those villages doing shifting cultivation and or expanding cultivation fields towards Selous Game Reserve should be discouraged to continue these practises.

- Those villages with no permanent infrastructure such as school buildings, dispensary, water supply etc. and located close to the reserve or located along the Selous animals corridor main feeding routes should be removed e.g. Tapika.

- Land use planning of the settlements to guide appropriate agricultural management techniques should be introduced along Selous ecosystem.

- The shooting of elephants due to crop protection is likely to continue if no immediate action will be taken by the relevant wildlife authorities. Introduction of non lethal methods is the only solution that can help to reduce or remove massive culling of elephants.

- Scientific data oriented to the nature and effects of controlling elephants both in terms of elephant population dynamics and of the people's crops damage should be collected in those villages adjacent to Selous Game Reserve.

- Selous Conservation Programme should consider to include Kilwa district in the community Based Conservation Programme in order to enable the people to benefit Wildlife like Rufiji and Liwale.

- Selous Conservation Programme should continue to train village Game scouts in most of all villages adjacent to the reserve, who will help to scare animals and each village should be supplied with enough shotgun blanks, thunder flashes and flares.

- To reduce the number of vermin animals, the relevant wildlife authorities should offer some sort of rewards to those local organised hunting groups that will kill the highest number of vermins like baboons, monkeys and bushpigs in a year.

- Through this paper advises to the Selous management and study districts are:
  (a) Encourage non lethal forms such as the use of combined shotgun blanks and flares, combined use of thunder flashes and flares, and the use of thunder flashes which can be done by the peasant alone in the field.
  (b) Encourage the use of traps, fences and trenches or ditches by the peasants so as to reduce vermin populations or prevent vermins to enter into cultivation fields.

  (c) Encourage indigenous researchers to study the existing conflict between elephants and people in those areas adjacent to the reserve. The scientific research and monitoring of elephants will improve the planning and management of all wildlife in the areas adjacent to the reserve.

- Through this paper advises to the peasants living adjacent to the reserve are:

  (a) Encouraging self defence for crop protection. Note that compensation for crop damage is not recommended. It discourages self defence and sometimes may exaggerate the damage problem.

  (b) Encourage organised hunting groups to depress the populations of vermins like bushpigs, monkeys and baboons.

  (c) Discourage shifting cultivation by establishing permanent settlements and cultivation fields.

TABLE 3: SUMMARY OF WILD ANIMALS KILLED ORE INJURED AND PEOPLE KILLED OR INJURED IN THE STUDY DISTRICTS IN THE PERIOD BETWEEN 1975 AND 1995

District	Species	numbers killed	numbers injured	people killed	people injured
Liwale	Elephant	3043	379	8	7
	Hippo	238	84	5	14
	Buffalo	174	14	1	11
	Lion	45	8	22	8
	Leopard	49	8	24	16
	Crocodile	nil	nil	0	0
	Hyaena	47	11	0	7
subtotal		**3596**	**504**	**60**	**63**
Kilwa	Elephant	2047	370	22	16
	Hippo	910	307	26	21
	Buffalo	47	6	7	8
	Lion	79	23	11	15
	Leopard	38	17	2	18
	Crocodile	12	3	4	7
	Hyaena	26	9	1	4
subtotal		**3159**	**735**	**73**	**89**
Rufiji	Elephant	1685	693	21	14
	Hippo	3100	1287	82	45
	Buffalo	116	32	49	14
	Lion	261	72	11	10
	Leopard	14	2	12	9
	Crocodile	659	84	56	25
	Hyaena	12	3	1	5
subtotal		**5847**	**2173**	**232**	**122**
total		**12602**	**3412**	**365**	**274**

TABLE 4: SUMMARY OF NUMBERS OF VERMIN KILLED ON CROP PROTECTION IN THE STUDY DISTRICTS BETWEEN 1975 AND 1995

District	Bush pig	Baboon	Vervet monkey	other Monkeys	Warthog	total
Liwale	1284	3408	2269	686	86	**7733**
Kilwa	2304	2473	1139	680	91	**6687**
Rufiji	4973	4254	1445	3747	859	**15278**
total	**8561**	**10135**	**4853**	**5113**	**1036**	**29698**

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