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Asian Elephants as Agricultural Pests: Economics of Control and Compensation In Sri Lanka

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ABSTRACT

Despite growing attention to crop and property damage caused by the Asian elephant, uncertainty exists about the magnitude of this problem. This article explores the nature and magnitude of this problem in Sri Lanka. An economic analysis of individual farmers' decisions to control elephants is provided. Government policies to assist farmers in coping with the elephant pest problem are assessed. Appropriate compensation schemes for farmers are seen as potentially more effective for conserving elephants in Sri Lanka than legal prohibitions on the killing of elephants. The issues raised here have wider relevance than merely to Sri Lanka or Asian elephants.

I. INTRODUCTION

Urban dwellers and farmers are often in conflict about the conservation of wild animals such as elephants, monkeys, and coyotes. Urban dwellers frequently favour legislation to protect such animals, while farmers who experience agricultural damages from such wildlife are aggrieved by such measures. This article demonstrates, by examining the Asian elephant as an agricultural pest in Sri Lanka, why farmers feel aggrieved by such legal protective measures. This is especially so when farmers are not adequately compensated for the economic damages they incur from such wildlife. The article also outlines compensation measures that may reduce this conflict and thereby assist in the long-term conservation of the animals concerned.

While the Asian elephant (*Elephas maximus*) captures the imagination and affection of many people worldwide for its use or non-use economic values, this species inspires animosity and fear as an agricultural pest among those competing with the elephant for the animal's natural habitats. Several recent studies highlight the antipathy of local farmers to

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Asian elephants. For example, Tisdell and Xiang[1] describe the dissatisfaction of the Chinese farmers living near the boundaries of the Xishuangbanna State Nature Reserve in Yunnan towards the elephants. Weerakoon[2] found that farmers and local communities in the northwestern province in Sri Lanka display ingrained hostility to elephants and they are the focus of local farmers' animosity toward wildlife. Ramakrishnan et al.[3] outline the fear of and distress caused by farmers and rural communities on the boundaries of the two elephant corridors, Sujalkuttai-Bannari and Kallar-Vedar settlements in South India. Aung[4] reports that the farmers in the vicinity of the Pidaung Wildlife Sanctuary in Myanmar consider elephants to be the most destructive species of wildlife. Moreover, rural communities on the border of the Way Kambas National Park of Sumatra complain bitterly about elephants, except where the animals have been eradicated.[5] Way Kambas National Park hosts the home range for the Sumatran elephant (*E.m.sumatranus*), a unique sub-group of the Asian elephant.

The animosity of the farmers and rural communities in the vicinity of the protected areas and other nature reserves is an unfavourable portent for future elephant survival, particularly given the trend toward decentralised wildlife management throughout the Asian elephant's range. Under current conditions, most local farmers would eliminate elephants from their environment if they could.[6] Therefore, conservationists must find ways to raise farmers' tolerance of elephants in Asia. This requires gaining a better understanding of elephants as an agricultural pest as well as exploring other means including adequate compensation to farmers for crops and property destroyed by elephants.

The Asian elephant has experienced a greater degree of habitat loss and fragmentation than its African counterpart. Consequently, the elephant populations in Asia have become concentrated in isolated protected areas and remnant forest habitats or islands, with their survival dependent

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1. *See* Clem Tisdell & Xiang Zhu, *Protected Areas, Agricultural Pests and Economic Damage: Conflicts with Elephants and Pests in Yunnan*, 18 ENVIRONMENTALIST, 109-18 (1998).

2. *See* Devaka K. Weerakoon, Ecology and Ranging Behavior of Wild Elephants and Human-Elephant Conflict in Sri Lanka viii (Dec. 15, 1999) (unpublished report, Dep't of Zoology, Univ. of Colombo, Sri Lanka) (on file with author).

3. *See* R. Ramakrishnan et al., *Human Interference and Its Impact on Elephant Corridors in South India*, GAJAH, July 1997, at 1.

4. *See* Myint Aung, *On the Distribution, Status and Conservation of Wild Elephants in Mynamar*, GAJAH, July 1997, at 21.

5. *See* Philip J. Nyhus & Ronald Tilson Sumianto, *Crop Raiding Elephants and Conservation Implications at Way Kambas National Park, Sumatra, Indonesia*, 34 ORYX 262 (2000).

6. *See* Catherine M. Hill, *Conflicting Attitudes Towards Elephants Around the Budongo Forest Reserve, Uganda*, 25 ENVTL. CONSERVATION 244, 247 (1998).

throughout Asia on the use of private or non-protected land.[7] Elephants often visit human settlements, commonly to feed on a wide variety of cultivated food and cash crops, sometimes causing damage to food stores, water installations, fences, and barriers and occasionally injuring or killing people. Thus, farmers are more likely to regard elephants as a dangerous agricultural pest and retaliate by injuring, killing, or using deliberate defensive measures to displace elephants.

Asian elephants are likely to endure further reduction of their natural habitat. At present, 20 percent of the world's population lives in and around areas inhabited by the Asian elephant. With the current annual average growth rate of 2.7 percent in Asia, the human population will be doubled within another three decades or so.[8] Thus, human population pressure on the Asian elephant ranges will increase with a corresponding increase in the demand for new land for human use. Moreover, fragmentation and loss of the elephant's natural habitats seem likely. The elephants continue to be in conflict with their human neighbours.

This situation is difficult to resolve. Farmers generally perceive elephants as property belonging to the state.[9] Farmers expect state institutions responsible for protected areas to also be responsible for control of the elephant and other wildlife. These institutions are generally ill equipped to monitor elephants and in turn are blamed by farmers for losses to crops and property.

In Sri Lanka, as elsewhere in the Asian elephant's range, the elephants are in conflict with their human neighbours throughout their range.[10] They are also responsible for much of the crop and property damage near the border of the protected areas of the country.[11] De Silva[12] concludes, on the basis of a study conducted in System G of the Accelerated *Mhaweli* Development programme, that crop depredation by elephants is the most common cause of human-elephant conflict. Santiapillai[13] estimates that about 30 to 50 people per year are killed in Sri Lanka by wild elephants, while approximately 100 to 120 elephants are killed by humans, primarily

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7. *See* Ranjith Bandara & Clem Tisdell, *Conserving Asian elephants: economic issues illustrated by Sri Lankan concerns*, *in* THE ECONOMICS OF CONSERVING WILDLIFE AND NATURAL AREAS 193, 195, 199-201, 206-08 (Clem Tisdell, ed. 2002).

8. *See* ELIZABETH KEMF & CHARLES SANTIAPILLAI, WORLD WILDLIFE FUND, ASIAN ELEPHANTS IN THE WILD 2 (2000).

9. *See* Nyhus & Sumianto, *supra* note 5, at 264.

10. *See* Mangala de Silva, *Status and conservation of the elephant and the alleviation of man-elephant conflict in Sri Lanka*, GAJAH, July-Dec. 1998, at 1, 1 (1998).

11. *See* AJAY A. DESAI, DEP'T OF WILDLIFE CONSERVATION, MANAGEMENT STRATEGIES FOR THE CONSERVATION OF ELEPHANTS AND MITIGATION OF HUMAN-ELEPHANT CONFLICT 96 (1998).

12. *See* de Silva, *supra* note 10, at 35.

13. Charles Santiapillai, *Human-Elephant Conflict Management in Sri Lanka*, SRI LANKA NATURE, Sept. 1998, at 5, 5 (1998).

because they interfere with agriculture. Desai[14] believes that the elephant pest problem in Sri Lanka is a direct outcome of the excessive changes in land-use patterns and the continued conversion of natural elephant habitat to human uses. Human land-use patterns in the former elephant range in Sri Lanka have changed remarkably and natural habitat available for elephant conservation has undergone a marked reduction over the last one hundred years or so.[15] During the pre-independence era,[16] a considerable portion of the natural habitat of elephants was utilised for the establishment of plantation agriculture in the wet and intermediate zones of Sri Lanka. As a result, elephants were almost completely obliterated from the wet zone and became restricted to the dry zone areas of the country. During the post-independence period, development of large-scale irrigation agricultural projects, such as the *Mahaweli* Development, made it possible for people to farm in the dry zone, and as a consequence a large number of settlements were established in the dry zone.[17] This has led to a further reduction and fragmentation of available elephant habitats resulting in alterations in their access to food and water and disruption of elephant home ranges and movement patterns. This situation has compelled elephants to extend their range into human settlements and agricultural fields in and around the protected area network in Sri Lanka.

Despite growing attention to crop and property damage caused by the elephant around protected areas, uncertainty persists about the actual magnitude of the elephant pest problem in Sri Lanka and elsewhere in the Asian elephant's range. Non-economists and technical experts from other disciplines claim that farmers universally exaggerate crop damage perpetrated by elephants and other wildlife.[18] Other studies suggest that elephants and other megafauna are unjustly blamed for damage, and that smaller animals, such as rodents or primates, cause much greater losses over time.[19] The high variability of the crop damage caused by elephants and inadequate data bases recording the damage hamper efforts to address this highly-charged political issue. To understand farmers' complaints, the spatial distribution, frequency, extent, and nature of crop loss must be examined. Moreover, the socio-economic factors, the status of public policies to assist farmers in controlling the elephant pest problem, and the resulting social welfare issues that shape local cropping strategies and

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14. *See* DESAI, *supra* note 11, at iv.
15. *See* Bandara & Tisdell, *supra* note 7, at 194.
16. This is between the years 1830–1948, when Sri Lanka was a British colony.
17. *See* DESAI, *supra* note 11, at 12-13.
18. *See, e.g.*, J.C. Daniel, *Conservation of Asian Elephant*, GAJAH, July 1996, at 1.
19. *See* Dr. Sarath W. Kotagama, *Interaction: Its Nature and Trends*, PROCEEDINGS OF THE SEMINAR ON CONSERVATION PLAN FOR ELEPHANTS OF SRI LANKA, Feb. 1997, at 29, 30; de Silva, *supra* note 10, at 25.

perceptions of risk should be analysed. Precise measurement and analysis of such factors are needed so that leading conservationists can respond to human-elephant conflict as a primary threat to elephant survival in Asia in general, and in Sri Lanka in particular. This article is intended as a step toward achieving this goal.

This article explores the economic aspects of elephant pest problems and the individual farmer's decision to control elephants as an agricultural pest. The nature and magnitude of the agricultural damage and economic loss caused by elephants are examined in the context of a case study conducted in the northwestern region of Sri Lanka. An economic analysis examines individual farmers' decisions to control elephants as an agricultural pest. The situation in Sri Lanka is used as a case study in assessing the status of government policies to assist farmers to control the elephant pest problem. The economic issues raised in relation to elephant crop damage in Sri Lanka are pertinent to other Asian countries, as well as to situations of other species of wildlife that cause damage for farming systems and crop production in the vicinity of protected areas and nature reserves.

In order to do this, the article proceeds by first providing a general overview of the elephant as an agricultural pest in Sri Lanka and the extent and nature of agricultural damages caused by the elephant. This is followed by an outline of results from a case study of economic losses suffered by farmers from elephant raids in northwestern Sri Lanka. It is hypothesised that economic losses from damage caused by elephants is the major factor shaping the attitudes of farmers to elephants and their individual decision to control or kill elephants. Economic factors likely to influence such control decisions are modelled. Government restrictions on the type of control measures that can legally be adopted by farmers are considered. These substantially reduce the economic benefits available to individual farmers from their control efforts and intensify the hostility of farmers to public conservation policies, particularly because of inadequate public schemes to compensate farmers for damages they suffer from raids by elephants. Both the delays in paying farmers compensation in Sri Lanka and the paltry amount of compensation eventually paid add to the farmers' frustration. There is little wonder that they are inclined to take the law into their own hands and destroy elephants illegally. It is argued that improved compensation schemes for farmers suffering elephant damages are needed if Asian elephants are to survive in the long-term in Sri Lanka. Therefore, proposals are outlined for improved compensation schemes.

II. AGRICULTURAL DAMAGE AND THE ELEPHANT PEST PROBLEM IN SRI LANKA

A. An Overview

Crop depredation by wild elephants is a common problem across the entire elephant range in Sri Lanka. Already significant, this problem has been aggravated by the establishment of several large river diversions and irrigation schemes designed to develop commercially viable agricultural practices in the last three to four decades.[20] Fernando[21] argues that most of these development schemes did not pay adequate attention to the habitat requirements of the elephant in the adjacent nature reserves and that this oversight may have increased the severity of crop raiding by elephants. Desai[22] describes the level of agricultural damage caused by elephants in relation to the types of interface between human use areas and elephant habitats. He identifies four types of interface: (a) the areas where there are substantial boundaries between major human use areas and major elephant habitats such as the *Mahaweli* project areas,[23] the level of crop damage in these areas is generally low; (b) the smaller human use areas in and around the non-protected areas of elephant habitats such as the western and northern boundary of Minneriya-Giritale,[24] this is the most common interface and the intensity of crop raiding in these areas generally varies depending on the degree of habitat conversion and fragmentation; (c) larger fragmented areas, such as the northwestern region, where the landscape is a mosaic of human-use areas and elephant habitats,[25] the most serious crop depredation by elephants is reported in these areas; and (d) the small elephant pockets or islands amidst human-use areas,[26] such elephant populations are responsible for very severe crop raiding because they need

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20. *See* Jayantha Jayewardene, *Elephants and Mahaaweli: A 15-Year Study*, SRI LANKA NATURE, Sept. 1998, at 3.

21. *See* A.B. Fernando, *Recent Elephant Conservation Efforts in Sri Lanka*, GAJAH, July 1993, at 19.

22. *See* DESAI, *supra* note 11, at 99-101.

23. *Mahaweli* is a multipurpose irrigation agricultural scheme established in the late 1970s in the dry zone in Sri Lanka.

24. This protected area was created to relocate the elephants displaced as a result of the *Mahaweli* project in the northwestern province.

25. *See* DESAI, *supra* note 11, at 99-101.

26. *See* Weerakoon, *supra* note 2, at 3.

to extend their movements into human settlements to survive and commonly feed on a wide variety of cultivated foods and cash crops.[27]

De Silva[28] examines the distribution of crop depredation by elephants in a study conducted to assess the present human/elephant conflict (HEC) in Sri Lanka. In this analysis, secondary data such as the deaths of both humans and elephants collected at the divisional secretariat level[29] were used to describe the distribution of HEC. This study reveals that elephant crop raiding is widespread in the northwestern region, especially in the Anurathapura district. The other districts of this region such as the northeastern part of Kurunagala district and the northwestern area of Mannar district also experienced severe elephant crop raiding. In the *Mahaweli* region, Systems C and D are critical areas of crop depredation by elephants. In the southern region, the agricultural damage from elephants was high in the Moneragala District and the eastern part of the Hambantota district. Syambalanduwa, Galkiriyagama, Navagatthegama, Karuwalagaswewa, Galoya, Mhavilachiya, the divisional secretariat areas, have also experienced significant crop depredation by elephants.

Santiapillai[30] examines the major causes for crop and property damage caused by elephants in the context of HEC management in Sri Lanka. According to his analysis, four factors are responsible for elephant interference in agricultural activities in the elephant region: (a) a rapidly growing human population,[31] (b) drastic changes in human land use patterns, (c) loss of forest cover, and (d) the ongoing civil strife in the country. The human population in Sri Lanka at the turn of the century was estimated to be 3.6 million, giving a crude density of 55 people per km^2. At that time, about 70 percent of land was under some form of a forest cover.[32] Today, the human population has increased to almost 19 million.[33] The area under forest cover has declined to about 20 percent and the area under cultivation has increased substantially.[34] As a result, elephants and farmers have become incompatible neighbours in many parts of the Sri Lankan

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27. For an outline of the reasons for the crop raiding behaviour of wild elephants *see* WWF AREAS Technical Support Network & Asian Elephant Research & Conservation Centre, Centre for Ecological Sciences, Indian Institute of Science, Elephant-Human Conflict: It's Reasons, Solution and Cost, Workshop Material 2-4 (2002) (unpublished document, on file with authors).

28. *See generally* de Silva, *supra* note 10.

29. The lowest level of provincial administration in Sri Lanka.

30. *See generally* Santiapillai, *supra* note 13.

31. *See id.* at 13.

32. *See* SRI LANKA MINISTRY OF FORESTRY & ENVTL. MGMT., STATISTICAL COMPENDIUM ON ENVIRONMENTAL STATISTICS—SRI LANKA: 1998, at 20 (1998).

33. Dep't of Census & Statistics, Sri Lanka, *2001 Population by Sex and Age, at* http://www.statistics.gov.lk/Documents/census2001/rep01/t001a.htm (last visited Aug. 27, 2002).

34. *Cf.* SRI LANKA MINISTRY OF FORESTRY & ENVTL. MGMT., *supra* note 32, at 19.

elephant range. They cannot live together without conflict where agriculture is the dominant form of land use.

Several studies by wildlife scientists on human elephant conflict in Sri Lanka have estimated the deaths of both humans and elephants in the areas where HEC prevails. For example, Santiapillai[35] estimates that a total of 1163 elephants lost their lives in the wild between 1950 and 1970, 639 (55 percent) of which were killed by farmers in defence of their crops. A total of 452 elephant deaths were reported between the early 1980s and mid 1990s in the northwestern and central provinces alone, of which 336 (or 74 percent) were killed by farmers.[36] This is equal to one third of the current elephant population in these provinces. Kemf and Santiapillai[37] reported that at present between 100 and 120 elephants on average are killed every year due to their damage to crops. There are no proper records of deaths of farmers in relation to elephant crop raiding or crop protection practices of farmers. However, people are also being killed by elephants for a variety of reasons throughout the elephant's range. Santiapillai[38] reports that on average 30 to 50 people are killed by wild elephants annually in Sri Lanka. According to Santiapillai,[39] within the past seven years over 500 people have lost their lives as a result of the conflict between humans and elephants. More men are killed by elephants than women and most of the fatal human-elephant encounters take place in the night.[40] In all reported cases, the elephants responsible for causing human deaths were lone animals, presumably bulls.[41]

In addition to the sectoral level studies cited above, a few case studies at the micro level have also been carried out to provide information on certain aspects of crop depredation by elephants. Jayewardene[42] estimates the annual agricultural losses incurred by farmers in System G of the Accelerated *Mahaweli* Development Programme. According to his estimates, crop loss ranged from Rupees[43] 10, 000 ($106.40) to Rupees 30,000 ($319.10) per farmer per annum. The farmers in this area predominately cultivate paddy (rice) during two cropping seasons per year. De Silva[44] estimates that the crop damage caused by elephants ranged between

35. *See generally* Santiapillai, *supra* note 13.
36. *See* de Silva, *supra* note 10, at 36.
37. *See* KEMF & SANTIAPILLAI, *supra* note 8, at 8-11.
38. *See* Santiapillai, *supra* note 13, at 6.
39. *Id.*
40. The elephants raid crops usually at night and in most cases the male members of farming families undertake crop protection practices and are therefore at greater risk.
41. *See* DESAI, *supra* note 11, at 96-101.
42. *See* Jayawardene, *supra* note 20, at 45.
43. The currency of Sri Lanka.
44. de Silva, *supra* note 10, at 36.

Rupees 5000 ($53) to Rupees 10,000 ($106.40) per cropping season per farmer in a sample of 200 farmers in the southern region during the *Maha* season[45] in 1997. Munaweera[46] examines the effectiveness of crop protection measures used by farmers in the boundaries of the Hadapanagala wildlife sanctuary. This study found that the effectiveness of the most current crop protection measures used by farmers is deteriorating due to increased resistance by elephants. Weerakoon[47] examined the nature of the crop protection practices used by farmers in a sample of 450 farmers in the northwestern region of Sri Lanka in 15 selected administrative divisions during the 1998/1999 *Maha* season. This study revealed that about 70 percent of the farmers in the sample practised crop protection measures.[48] The most common methods utilised included standing guard in a hut with a stock of firecrackers that they intended to throw at elephants to scare them. Some of the farmers also possessed shotguns.[49]

In summary, the literature cited in this section reveals that human-elephant conflict is a common problem across the entire elephant range in Sri Lanka and the management of problem elephants has become a serious issue. Moreover, this problem adversely affects both people and elephants. People suffer when elephants raid crops, damage property, and cause bodily harm, even death. Elephants in turn suffer due to increased mortality primarily because of farmers' attempts to protect their crops. However, we found that there is an information gap and that a better understanding of farmers' complaints about wild elephants as an agricultural pest is needed. The following section investigates this issue in detail.

B. A Case Study of Crop Damage, Control Measures, and Incidence of Raiding by Elephants

To understand better the farmers' complaints and their decision to control elephants as agricultural pests, a six-week field study was carried out from July fourteenth to July twentieth 2001 by one of the authors of this article in the Galgamuwa divisional secretariat area in the northwestern region of Sri Lanka during the post-harvesting period of the 2000/2001 *Maha* season. A random sample of 300 farmers was chosen from six selected villages in three *Gramaniladari* divisions (the lowest local government administrative unit in Sri Lanka) on the basis that they experienced a high

45. The main cropping season in Sri Lanka.

46. *See generally* D.P. Munaweera, *Handapanagala: A Study in Human-Elephant Conflict Management*, SRI LANKA NATURE, Sept. 1998, at 66.

47. Weerakoon, *supra* note 2, at viii.

48. *Id.* at 20.

49. De Silva, *supra* note 10, at 38.

level of crop damage as estimated by Weerakoon.[50] Three of these villages in the sample (Karuwalagas wewa, Raswhera, and Meegalawa) are located within the northern boundary of Wilpatthu National Park and the other three (Galkiriyagama, Makulawa, and Itharandeniya) are adjacent to the park. The northwestern region supports a comparatively large elephant population of around 1500 animals.[51] However, there are only a few protected areas in this region and they are not large enough on their own to support an elephant population of this size. 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 study area, farmers were asked to respond to a series of questions. These questions were asked 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 caused by elephants, the nature and the effectiveness of crop protection methods, and farmers' general perceptions of the elephant.

Seventy-seven percent of the respondents believed the elephant pest problem had grown worse over the last ten years. The rest of the respondents reported that the problem has been stable and the incidents of elephant crop raiding have always been frequent. A total of 24 different crops were reported as being cultivated by farmers in the sample. These crops include paddy (rice), maize, millet, sorghum, green gram, soybeans, cowpeas, mustard, cassava, beans, green chilli, bananas, coconuts, and a variety of local vegetables. For the purposes of this study, we concentrate on the crops people consider central to their subsistence, namely paddy, green chilli, banana, maize, cassava, and mango. Farmers were asked to rank these crop varieties in descending order according to the degree of crop damage caused by wild elephants. In this ranking process, they were also asked to consider their experiences during the last five years of elephant crop raiding. Table 1 presents the farmers' ranking of the crop damage caused by elephants and the frequency with which such crops were being grown.

50. *See* Weerakoon, *supra* note 2, at 20.
51. *Id.* at 23.

TABLE 1: FARMERS' RANKING OF CROP DAMAGE CAUSED BY WILD ELEPHANTS IN THE SAMPLE

Crops Cultivated	Ranking according to amount of damage caused	Ranking according to frequency of cultivation
Paddy	1	1
Green chilli	6	2
Banana	2	3
Maize	3	4
Cassava	4	5
Mango	5	6

Farmers considered paddy, bananas, and maize the crops most vulnerable to elephant raiding. An important consideration is whether particular crops are more vulnerable to attack by wild elephant than others. There are a number of key factors to be considered, including the growth stage at which a crop suffers damage, the diversity of the farm, the feeding habits of the individual elephants, the size of the elephant herd, the time of day, and the month of the year or cropping season. Elephants raid crops throughout the year but raid more intensely during certain months. Elephants usually raid paddy fields in January when the grain is maturing and continue their raids until harvesting is completed in April. During this period, other cereals and vegetables are grown on high ground and in *chenas* (temporarily cleared areas in the forest), which are also raided. After the paddy harvest, cash crops such as green chilli and onions are grown in paddy fields. Elephants raid these crops during the period of April to September. Bananas are attacked at all stages of development. Mango trees are attacked during the fruiting seasons, May through June and November through December. Elephants also attack the permanent crops, such as jackfruit and coconut, particularly when other crops are not available on their usual raiding routes. Weerakoon[52] provides a detailed account of the ecology and ranging behaviour of wild elephants in Sri Lanka. Of the elephants causing damage, 43 percent were solitary bulls, 38 percent were bull groups, and 19 percent were herds. Most of the attacks took place between 1900 and 0100 hours and in the early morning hours.

52. *Id.* at 11-13.

The extent of crop damage caused by elephants was assessed in relation to three major farming practices: home gardens, lowland cultivation (agricultural practices undertaken in irrigated farming fields in lowland areas), and *chena* cultivation (agricultural practices undertaken in temporary farming fields created for only two to three cropping seasons by clearing forest and bushland in the highland areas). The links between the issues of land scarcity and vulnerability of elephant crop raiding were examined in relation to socio-economic conditions of Sri Lankan farming families. Most of the farmers in the sample operated small-scale farms and usually belonged to a lower income category. Many of them lived in impoverished conditions with little education and limited or no health facilities. Only a small percentage of young farmers have their own farming fields. Most of the farms either belong to their parents or are illegally occupied state-owned lands. Fragmentation of the existing farming fields and land scarcity were reported to be the major issues that influenced family disputes, alcoholism, and crimes in this area. The government and local authorities blame the farmers for not taking any serious action to resolve these problems.

The average size of a land holding by a farming family in the study area is about 1.28 hectares, of which about 32 percent is represented by *chena* land. The vulnerability to crop damage in *chena* cultivation is reported to be little higher than for the other two farming practices. This is because *chena* cultivation mostly takes place either in forest patches adjoining human settlement in the highland areas or inside the protected areas. The mean extent by type of farming fields per farming family and the value of crop damage caused by elephants according to major farming practices are presented in Table 2.

Farmers had little complaint about crop damage caused by other wildlife. The general impression of the farmers in the study area is that ordinary agricultural pests such as insects, wild pigs, rats, and monkeys can easily be managed with less effort and at less cost. Elephants, however, are not easy to control due to their size and are more destructive. The farmers also explained why low crop damage was recorded in home gardens in this area. Home gardens are planted near houses. Therefore, elephants are not inclined to risk this type of crop raiding, as the chance of farmer retaliation is definite in such locations. The farmers believe that elephants are intelligent animals and they well understand human movements as they often raid crops by avoiding the artificial barriers erected by farmers.

Strategies used by farmers to reduce crop raiding by elephants range from individual and household efforts to those that require community participation or outside support. Farmers in the sample were asked to give details of the methods they employ to deter wild elephants from destroying their crops. The majority of farmers reported that they relied on "scaring and chasing" methods to control elephant crop raiding in the study area. They also stated that guarding their own fields is one of the most effective methods of preventing the elephants from entering their farming fields. Huts or watchtowers are constructed along the boundary of farms where elephants frequently enter fields. When elephants are spotted, farmers use a combination of loud noises, including yelling, firecrackers, hitting metal objects, and cracking whips. Bright lights, including flaming torches and powerful flashlights, are also used to frighten the elephants. Direct contact with elephants is less common, but objects are thrown and some farmers move close enough to use whips. These methods have reportedly become less effective over time, as the crop-raiding elephants soon learn to ignore these deterrents and develop resistance to crop protection measures. Consequently, elephants have developed no fear of such control measures and continue to raid the cultivated fields for easy fodder, especially when their natural habitat is insufficient to support their nutritional needs.

The extent of use by farmers of methods such as poisoning, shooting (with firearms), and trapping to control elephant crop raiding in this study area is unclear. Farmers were reluctant to reveal the details of the use of these methods because the elephant is a protected species. Killing an elephant is an unlawful act that can result in imprisonment or fines.[53] Nevertheless, farmers do use such measures to control the elephant in this area. Weerakoon[54] revealed that this region (the northwestern) recorded the

53. The minimum penalty for killing an elephant in Sri Lanka is three years of imprisonment or a fine worth Rupees 300,000 ($3,000).

54. Weerakoon, *supra* note 2, at 23.

highest mortality rate of elephants in Sri Lanka between 1990 and 1999. According to his estimates, 341 elephant deaths were recorded in the area during this period, of which 224 (66 percent) were male elephants (including 12 tuskers), 68 (25 percent) were female elephants, and 30 (9 percent) were of undetermined sex owing to degradation of the carcass. The main causes of death were gunshot injury (57 percent), followed by electrocution (5 percent), accident (4 percent), and land mines (3 percent).[55]

The incidence of crop raiding attempts by elephants was used as an indicator to evaluate the effectiveness of the damage control methods used by the farmers in relation to major farming practices. The relative effectiveness of these methods was examined by comparing the number of incidents of elephant attack with the use of control methods. A summary of the main findings for the incidence of crop raiding attempts by elephants is presented in Table 3. A total of 224 farmers (74 percent) in the sample used some form of protection to safeguard their crop cultivation, 135 farmers (66 percent) still experienced crop damage. Altogether, a total of 181 farmers (60 percent) experienced crop damage regardless of whether crop protection measures were used or not. In other words, the crop protection measures, even violent techniques used by the farmers, to a considerable extent were relatively ineffective in preventing elephants from entering their farming fields for crop raiding.

TABLE 3: THE INCIDENCE OF ELEPHANT CROP RAIDING ATTEMPTS IN RELATION TO THREE DIFFERENT FARMING PRACTICES AND THE RELATIVE EFFECTIVENESS OF CROP PROTECTION METHODS (n=300)

Major Farming Practices	Crop protection measures used		No crop protection measures used		Total incidence of crop raiding
	Number of farmers	Incidence of crop raiding[a]	Number of farmers	Incidence of crop raiding[b]	
Home garden	26 (12%)	16 (62%)	49 (65%)	14 (29%)	30 (16%)
Low land	136 (61%)	82 (70%)	14 (18%)	23 (67%)	105 (58%)
Chena	62 (27%)	37 (59%)	13 (17%)	09 (69%)	45 (24%)
Total	224 (74%)	135(66%)	76 (26%)	46 (48%)	181 (100%)

a. The incidence of elephant crop raiding as a percentage of the number of farmers who used crop protection measures in relation to different farming practices. b. The incidence of crop raiding as a percentage of the number of farmers who did not use crop protection measures in relation to farming practice.

The other important aspect uncovered in this study is the importance of the stakeholder's perception of the wild elephant as a pest or

55. *Id.* at 23.

an asset. Differences in perception among the stakeholder groups (mainly farmers, private landowners, and local wildlife officials) can easily exist and such situations can easily lead to miscalculations of the management action required to conserve or eliminate the wild animal in question.[56]

A marked difference was observed to exist between the perceptions of farmers and local wildlife officials in the northwestern region in general and the study area in particular. The local wildlife officials unanimously believed that the current elephant population should be maintained intact in this region for ecological reasons. They argued that if elephants in this area were fragmented into small groups, the elephant would become even more vulnerable to extinction due to demographic, environmental, and genetic stochasticity. Officials also believe that this ecological objective can easily be achieved within the limits of existing national parks in the region if human encroachments into these parks are terminated. In contrast, most farmers in this area view elephants as a major threat to their livelihood and consider them agricultural pests. Moreover, farmers unanimously supported the idea that at least half of the current elephant population in this area should be removed to reduce the pressure on national parks and to protect agricultural fields. This difference in the perceptions of farmers and local wildlife officials presents a dilemma in determining the status of the elephant as an agricultural pest or an environmental resource.

In summary, the findings of the case study presented in this section reveal that the farmers' complaints about wild elephants as an agricultural pest were closely associated with at least three major reasons: (a) an increase in intensity of the crop and property damage caused by elephants, (b) decreases in the effectiveness of the current crop protection measures used by farmers, and (c) poor compensation for crops and property damage caused by elephants and lack of incentives to raise farmers' tolerance of the presence of elephants on the farming fields. Thus, the economic rationale of the farmers' decision to control elephants as an agricultural pest is discussed in the following section.

III. ECONOMIC ANALYSES OF INDIVIDUAL FARMERS' DECISIONS TO CONTROL ELEPHANTS AS AN AGRICULTURAL PEST

Most farmers in the vicinity of protected areas and other nature reserves regard the elephant as an agricultural pest, liable to damage their crops and imperil their livelihood. However, these farmers may consider elephants in a positive light if they remain in their natural habitat or cause

56. Clem Tisdell, *Wildlife: A National Asset or a Pest to Be Managed?*, *in* ENVTL. ECON., May 1978, at 79, 80.

very little agricultural damage.[57] Moreover, such positive attitudes of farmers toward the elephant may be influenced by the cultural or religious significance of this species of wildlife. For instance, in predominately Hindu and Buddhist Asian cultures, the elephant has an important place in the history, religious beliefs, folklore, mythology, and ceremony. Nevertheless, non-farming communities such as tourists, nature-lovers, and conservationists worldwide consider the elephant to be a valuable resource for recreational purposes, for its contribution to biological diversity, and for non-use values.[58] Thus, the individual farmer's decision to control the elephant as a pest certainly would conflict with the interests of non-farming communities who regard the elephant as a valued resource. However, the problem is how these two broader objectives can be reconciled.

Tisdell and Xiang[59] present an economic analysis based on the criterion of Kaldor-Hicks in determining an economically optimal level of control of a species population that is considered a pest as well as an asset. In this analysis, they argue that the optimal level of the population of a species, to maximise its net social economic benefit (its value as an asset minus its economic damage as a pest) is a function of its population taking into account the cost of varying the level of its population. Thus, if a species is, on balance, a pest at its current level of population, it is optimal to reduce its population to the level where the marginal cost of the value of reduction in its population equals the marginal reduction in economic damage caused by a population of wildlife less any loss in value experienced by those who favour an increased population of the species. Figure 1 illustrates the application of this analysis in the context of elephant conservation.

57. Tisdell & Xiang, *supra* note 1, at 109-18.

58. The non-use values of elephants include non-marketable intangible benefits that people derive from conserving them: for example the social, historical, cultural, and religious value of elephants.

59. *See generally* Tisdell & Xiang, *supra* note 1.

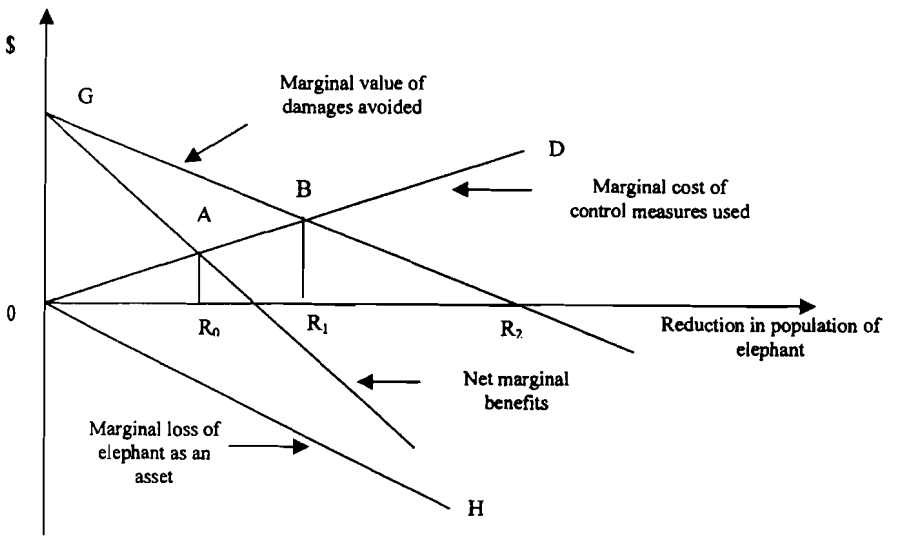

FIGURE 1: DETERMINING THE SOCIALLY OPTIMAL LEVEL OF CONTROL OF ELEPHANT POPULATIONS USING THE KALDOR- HICKS ECONOMIC CRITERION.

The line OABD represents the marginal cost of reducing the elephant population and holding it at its reduced levels. Line GB represents the marginal value of damage avoided as a result of this reduction of elephant population. The marginal loss for people who consider the elephant to be an asset is depicted by line OH. The line GA represents the marginal net benefit to the community in the reduction of the number of elephants present on farming lands. Line GA is found by subtracting the relationship OH from GB. The Kaldor-Hicks socially optimal level of a reduction of elephant population therefore is denoted by the point R_0, that level for which the marginal net benefit of the reduction equals its marginal cost. However, in this analysis the authors point out that the optimal level of reduction will be higher than the point R_0 if that particular species of wildlife is solely regarded as an agricultural pest. In this case, the optimal level of reduction of the elephant population is R_1.

The available evidence suggests that the farmers who suffer agricultural and property damages in the boundaries of nature reserves in Asian elephant ranges consider the elephant as an agricultural pest or a

dangerous nuisance.[60] This negative attitude, the unpleasant experience, and the economic damage resulting from elephant crop raiding often provide the necessary motivation for farmers to treat crop-raiding elephants harshly. The farmers' decision to control such problem elephants as an agricultural pest (or otherwise) is largely economic and does not significantly differ from their decision to control any other ordinary agricultural pests. The selection of crop protection methods and the level of reduction of elephant numbers present on the farm are determined by the individual profit maximisation attitudes of the farmer. The farmers' preferred level of reduction of elephants often exceeds the socially optimum level of reduction. Therefore, to regulate farmers' decisions about elephant control, the wildlife authorities rely on existing laws[61] that restrict the farmers' selection of elephant control measures. This compels farmers to undertake relatively ineffective crop protection measures in defending their crops if they decide to control elephants.

Figure 2 illustrates the basic economics of decisions by individual farmers to control elephants. If cost curve 1 control applies, no control is optimal by the individual farmer. If cost curve 2 applies, a reduction in the presence of elephants by x_1 maximises the farmers' net gain. The first situation is more likely to prevail if control techniques are relatively ineffective, if the value of crop damage is low, or if elephant raids on crops are infrequent, all other things being equal. The survey results reported in Table 3 seem to agree with this statement. Those farmers not adopting measures to protect crops against elephant raids had a lower incidence of crop raiding attempts by elephants (48 percent) compared to those taking control measures. The latter reported an incidence of attempted raids of 66 percent.[62] The loss avoided function would be lower in the former case than the latter case, and control would be less likely to be optimal in the former case, all other things remaining equal.

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60. *See* Tisdell & Xiang, *supra* note 1, at 112; Ramakrishnan et al., *supra* note 3, at 12-14; Aung, *supra* note 4, at 22-24.

61. *See* National Environment Act No. 47 of 1988 and No. 56 of 1998, Ministry of Forestry and Environmental Management Colombo, Sri Lanka (1998), *at* http://www.unescap.org/drpad/publication/integra/volume3/srilanka/3srindex.htm (last visited Aug. 12, 2002).

62. *See* Table 3 for further details.

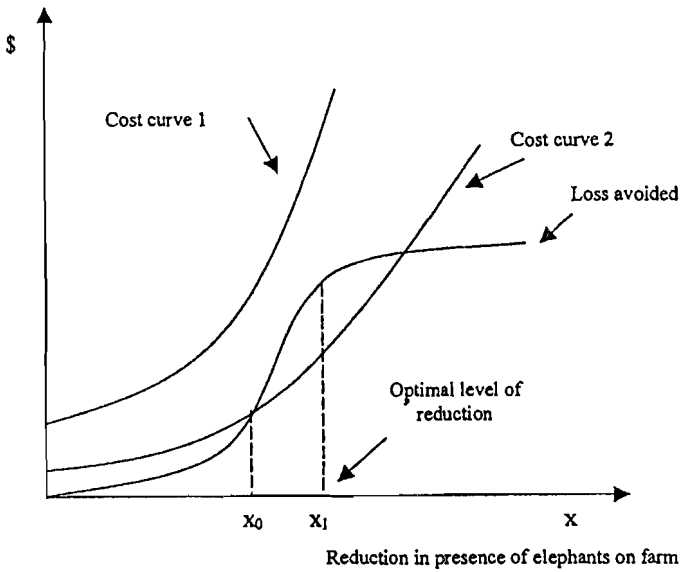

FIGURE 2: INDIVIDUAL FARMERS DECISION TO CONTROL ELEPHANT AS AN AGRICULTURAL PEST

The optimal control condition can be further elaborated mathematically. Assume that x represents the reduction in the presence of elephants on a farm. Then the net benefit of control can be expressed as

$$R = f(x)-C(x) \qquad (1)$$

where R is net benefit to the farmer, $f(x)$ is the value of loss avoided by the farmer and $C(x)$ is the cost of control measures.

For control to be profitable, $f(x)$ must exceed $C(x)$ for some value of x. If there is a positive profit-maximising level of control, then x should be chosen so that

$$f'(x) = C'(x) \qquad (2)$$

that is, so that the marginal net benefit from reducing the presence of elephants on the farm equals the marginal cost of doing this. In addition, the second order condition for a maximisation should be satisfied. Now, total cost will usually consist of a fixed and variable cost component. Thus;

$$C(x) = A+g(x) \qquad (3)$$

where A is the fixed or start-up cost and $g(x)$ is the variable cost. Other things being equal, $C(x)$ is more likely to exceed $f(x)$ for all x the larger is A or the greater is $g(x)$. Alternatively, the lower is $f(x)$, the value of loss avoided by the farmer, other things being equal, the more likely it is that no control is profitable from the point of view of the individual farmer.

If the control methods are unprofitable or relatively ineffective in achieving the expected level of reduction of elephants in farms, it is difficult to expect farmers to have positive attitudes toward the government policies for elephant conservation. For instance, farmers frequently express their anger toward the injustice of receiving little remuneration should they be injured or killed by an elephant, while facing stiff jail terms and fines if they hurt elephants.[63] When there is significant agricultural damage or loss of life occurs, farmers near the boundaries of the nature reserves believe they should be compensated for bearing the brunt of the cost associated with having large populations of elephants in the vicinity of their agricultural fields and settlements. However, at present, many countries in the Asian elephant range do not have regular systems or public policies in place to assist farmers in protecting their crop production from wild elephants or to compensate them for the crop losses and human injury or deaths caused by elephant attacks.[64] Some countries, such as Sri Lanka, have some programmes to compensate for crop damage and human injury or deaths caused by crop raiding elephants, but they are perceived by farmers to be inadequate.[65] Therefore, it is timely to review such compensation schemes.

IV. THE PRESENT STATUS OF GOVERNMENT POLICIES TO ASSIST FARMERS ADVERSELY AFFECTED BY ELEPHANT DAMAGE IN SRI LANKA

In Sri Lanka, a comprehensive national policy for elephant conservation and mitigation of human-elephant conflict has yet to be developed. Desai[66] sees the absence of such a policy and clearly defined management strategies as the major reasons for unresolved HEC in the country. However, several government agencies, such as the Department of Wildlife Conservation, the *Mahaweli* Authority, and the Department of Social Welfare have been involved in polices to alleviate elephant crop raiding and the resulting HEC over the last three decades.[67] Most policy

63. This was revealed from the informal discussion one of the authors of this article had with the farmers of the case study presented in section II.

64. *See* KEMF & SANTIAPILLAI, *supra* note 8, at 7-13.

65. A detailed discussion on farmer compensation schemes in Sri Lanka is presented in section IV.

66. DESAI, *supra* note 11, at 31.

67. Jayewardene, *supra* note 20, at 46.

actions taken by these organisations seem to be transient measures and have been taken largely to tie over a particularly critical time on an ad hoc basis.[68] De Silva [69] summarises actions taken by the Department of Wildlife Conservation (DWC), the primary agency in charge of conservation in Sri Lanka to assist farmers in the HEC-affected areas since the mid 1970s. These measures include (a) capturing and translocating problem elephants known to be habitual crop raiders or the cause of human deaths and injuries, (b) promulgating protected areas, (c) establishing deterrents to elephant movements such as the erection of electrified fences, elephant-proof trenches to keep elephants away from human settlements and cultivated areas, (d) rehabilitating elephant drives and traditional migratory paths, and (e) compensating for loss of life and damage to crops and property.

The overall effectiveness of these actions is still largely unknown. So far, no sustained effort has been made to evaluate the effectiveness of the DWC actions. However, some useful information can be found in the progress reports and internal evaluations carried out by the staff members of the DWC. Fernando[70] believes that most of these actions have been mainly ineffective. Bandara and Tisdell[71] observe that the problems experienced by the farmers in HEC-affected areas have remained unchanged over the years. Crop depredation by wild elephants remains a major problem. De Silva argues that the actions of DWC would be far more effective if they were part of an overall plan for elephant conservation.[72]

The general impression of the Sri Lankan policy makers and other interested parties such as non-governmental organisations and wildlife activists is that Sri Lanka needs new policies and programmes for elephant conservation and mitigation of farmer-elephant conflict. Such policies must adequately address compensating farmers for the economic losses of the agricultural and property damage caused by raiding elephants. Otherwise, farmers will not tolerate elephants near or on their farms. Most farmers in the HEC-affected areas are small-scale and have low incomes. Therefore, they require consistent and quick recovery plans for their economic losses and agricultural damage caused by elephants. Elephants and other wildlife will decline and eventually disappear from agricultural areas in Sri Lanka unless the farmers are promptly and adequately compensated for damage caused by wildlife. Other actions such as the construction of electric fences, translocation of problem animals, and rehabilitation of elephant drives

68. Weerakoon, *supra* note 2, at 2.

69. De Silva, *supra* note 10, at 43.

70. Fernando, *supra* note 21, at 21-23.

71. *See* Ranjith Bandara & Clem Tisdell, Rural and Urban Attitudes to the Conservation of Asian Elephants in Sri Lanka: Empirical Evidence (2002) (unpublished paper, on file with authors).

72. *See cf.* DESAI, *supra* note 12.

could be used as part of a medium-term solution to the elephant pest problem. The long-term conservation of wild elephants and mitigation of the elephant pest problem in Sri Lanka calls for integrated policies involving both public and private landholders.

The DWC of Sri Lanka manages the only plan in the country paying compensation to farmers for loss of life, injuries, and crops and property damage caused by elephants in HEC-affected areas. Earlier, there was also an additional scheme under the Department of Social Services to pay compensation for elephant damage. This was operated through the Divisional Secretary's offices in respective districts. However, this payment scheme has been suspended for the last three years for undisclosed reasons. At present, the highest payment is paid for the loss of life of the head of a household, about Rupees 50,000 ($532). If an adult who is not the chief householder is killed, the maximum amount paid is Rupees 35,000 ($373). For injury or damage to property, the compensation is less.

These payments are financed by the Insurance Corporation of Sri Lanka. According to DWC sources, the Ministry of Home Affairs pays Rupees two million ($21,280) as an annual insurance premium to the Insurance Corporation from its annual budgetary allocation. In 1999, this company paid Rupees 2.9 million ($30,856) in compensation to the farmers in the HEC-affected area. When this amount is compared to the annual elephant damage estimated by Jayewardene[73] and De Silva,[74] the compensation paid by this company only covers about three to eight percent of the actual economic losses caused by elephants. Therefore, there is little doubt this scheme is inadequate. Note also that the Insurance Corporation made a loss on this insurance.[75]

Farmers in the sample interviewed in the northwestern region of Sri Lanka expressed five main grievances about the existing elephant damages compensation scheme:

(1) There is a long delay before any compensation is paid.

(2) Compensation payment is very low for the property damage suffered.

(3) Compensation for loss of life is unbalanced, as the death of a young person who is not the head of the household but who has potential future earning

73. Jayewardene, *supra* note 20, at 45.

74. *Cf.* De Silva, *supra* note 10, at 19.

75. This was revealed from the informal discussion one of the authors of this article had with the officials of the Sri Lanka Insurance Corporation in Colombo, Sri Lanka.

capacity is not taken into account. The overall amount is also not adequate.

(4) There is a lengthy documentation and assessment process.

(5) No compensation payment for perennial and semi-perennial crop damage is made.

(6) There is no provision in this scheme to compensate for the death of a female, including a female head of household.

The issues of long delay and inadequacy of compensation payment made by the DWC were analysed by using secondary data.[76] A sample of 650 cases of elephant attacks reported to the six selected *Grama Niladahri's* offices[77] (GNO) between January 1997 and January 2001 was used in this analysis. The supplementary data was gathered from the Divisional Secretariat office (DSO) and the Regional Wildlife Office (RWO) at Galgamuwa in the northwestern region of Sri Lanka.

TABLE 4: THE DELAY BETWEEN THE DATE OF DAMAGE AND THE DATE OF APPROVAL OF PAYMENT (N = 650)

Duration (in weeks)	Number of complaints received at GNO	Number of reports received at DSO	Number of reports received at RWO	Number of payments approved at WDC
1 - 8	164	69	24	-
9 - 17	152	107	56	-
18 - 26	158	123	49	14
27 - 35	176	87	68	79
Total	650	386 (59%)[a]	197(51%)[b]	93 (47%)[c]

a. % of the total number of complaints received by the GNO. b. % of the total number of reports received by the DSO. c. % of the total number of reports received by the RWO.

From Table 4, it is apparent that there is a very long delay between the date of damage and the actual date of payment approved by the DWC in Colombo (see Table 4). It was revealed that the DWC approved about 50 percent of the reports received from the RWO within 10 to 12 weeks;

76. The results of this analysis are presented in Table 4.

77. The GNO is the official central government representative at the village level.

however, there was a long delay at the local GNO, DSO, and RWO. When there is elephant damage, the complaint has to be made at the GNO. The *Grama Niladahri* sends his report to the DSO. The officer in charge in the DSO forwards the *Grama Niladahri*'s report to the regional wildlife office for assessment, who then forwards it to the DWC head office in Colombo. In this process, first there is delay in time at the GNO for the preparation of the report that is sent to the Divisional Secretariat office. This delay is about four to six weeks on average; it sometimes takes a little longer if there are many complaints, particularly during the dry season. It takes about four to eight weeks on average for the DSO to forward the *Grama Niladahri*'s report to the RWO. It takes another eight to ten weeks on average for the RWO to send his assessment of a farmer's complaint to the DWC head office in Colombo for payment approval. The officer in charge at the DWC head office takes at least 10-12 weeks, on average, to grant approval for the payment. These long delays at each of these government agencies are attributed mainly to the bureaucratic rigidities and lack of inter as well as intra agency communication. However, the long delay in payment of compensation minimises its benefits and aggravates the farmers' disappointment about this compensation scheme. Delays of four to six months in payment of compensation seem to be the rule.

Despite the long delay in making payments, the amount paid as compensation for real property damage is very small. Table 5 presents the differences between the amounts claimed by the farmer and the amounts actually paid. What is very clear is that there is a decreasing amount paid as compensation irrespective of how high the claim is. The average claim was Rupees 5944 ($63) while the average amount paid was Rupees 1082 ($11.50). This brings to light the problem of paying compensation; the affected people usually inflate their claims in the hope of getting a reasonable compensation, knowing that the DWC will always pay less. Our assessment in the field showed that the affected people always claimed high amounts that they could not justify at the site of damage. However, they gave examples of compensation paid where the amounts received were far less than the actual damage. This too adds to the frustration of affected farmers.

TABLE 5: PERCENTAGE OF CLAIMED AMOUNT PAID AS COMPENSATION FOR CROP AND PROPERTY DAMAGE (N =93)

Compensation claimed by farmers (in Rs)	Actual amount paid (in Rupees)	% of claimed amount paid as compensation
1000 – 2000	410 - 820	41%
2001 –5000	420 - 1050	21%
5001 – 8000	850 - 1360	17%
8001 – 10000	1040 - 1300	13%
10,001 - 25,000	1100 - 2750	11%
25,001 - 50,000	1750 - 3500	7%

Compensation for crop damage was very low. It involved the same problems as that of the property damage claims with the added burden of the need for additional verification and paperwork, and, thus, further delays in an already slow system. Our preliminary discussions with local farmers in the northwestern region during the fieldwork for the case study indicate that the amount of compensation paid in general is far from adequate. The farmers believe that compensation for crop damage is quite inadequate and takes too long to reach those affected, sometimes taking more than two years after the damage is reported.

Finally, we sought from farmers their attitudes to an alternative compensation scheme. Most farmers expressed their willingness to contribute an equivalent of Rupees 100 ($0.106) per month if a self-financed compensation scheme is developed in the area. A scheme of this type could be developed by local authorities such as a provincial council or local multipurpose co-operative society along with non-governmental organisations. This may entail setting up a committee (including a few farmer representatives) to manage the funds and decide the compensation rate and would surely be an improvement on the existing scheme. Such a fund might be strengthened with corpus grants (where the capital remains untouched and only interest is spent) from national and international conservation agencies or from other groups that view the elephant as a positive resource.

This raises the question, however, of whether farmers should bear the cost or most of the cost involved in conserving elephants that do not respect private property. If the beneficiaries from conservation of elephants are non-farmers, including conservationists, a case can be made for them to pay a substantial amount of the cost imposed on farmers. Their contribution is likely to be important as a step toward the long-term survival of Asian elephants in Sri Lanka because this depends on elephants being able to use

areas other than protected ones. Without such compensation, the type of Kaldor-Hicks economic optimum shown in Figure 1 is unlikely to be achieved.

Nevertheless, crop insurance, and insurance in general, usually involves at least two problems. First, there is the moral hazard problem—the possibility that the insured will take less care to protect the crop from environmental damage if it is insured. Secondly, the insured and the insurer usually have different sets of information—asymmetry of information exists.[78] This makes it difficult for the insurer (and others) to know whether the insured will take reasonable care to protect the insured property and whether the claims of the insured for damages incurred have been inflated.

Some theoretical aspects of moral hazard[79] and crop insurance are reviewed by Vercammen and von Kooten.[80] However, an article by Rollins and Briggs[81] is more directly relevant to the consideration of payment of compensation to farmers for damages caused by elephants in Sri Lanka. Although it is not completely relevant because it focuses only on farmers and recreational hunters and recreational hunting of elephants is not permitted in Sri Lanka, the following observation by Rollins and Briggs[82] seems to hold generally:

> The moral hazard problem arises because of uncertainty inherent in wildlife management and damage abatement techniques. Because directly monitoring on-farm abatement effort is often prohibitively expensive, uncertainty in abatement techniques generates asymmetric information between payers and recipients of compensation. The information asymmetry precludes enforcement contracts that directly specify levels of abatement.

In the Sri Lankan case, however, reduced control of elephants by farmers would not necessarily be a negative result but could be a desired social outcome. The compensation may be important to encourage farmers to allow elephants some access to their crops for food and survival and

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78. *See cf.* R.G. Chambers, *Insurability and Moral Hazard in Agricultural Insurance*, 71 AM. J. ECON. 604 (1989).

79. "Moral hazard" is the tendency of the insured to expose the insurer to extra risk by reducing care of insured property. For example, compensation for crop damages discourages farmers from bothering to undertake crop protection measures to protect their crops from elephants.

80. *See* J. Vercammen & G.C. von Kooten, *Moral Hazard Cycles in Individual-Coverage Crop Insurance*, 76 AM. J. ECON. 250 (1994).

81. *See generally* Kimberly Rollins & Hugh C. Briggs III, *Moral Hazard, Externalities, and Compensation for Crop Damages from Wildlife*, 31 J. ENVTL. ECON. & MGMT. 368 (1996).

82. *See id.* at 369.

reduce the likelihood of the killing of elephants. Still, it may be difficult to ensure that access is kept to socially optimal levels and to deal with inflated claims for damages.

Given the existence of moral hazard, the greater the compensation payable to the insured in the event of a loss, the less is the incentive for the insured to protect his/her asset against an unfavourable event. Thus, the greater the compensation paid to farmers for damage by elephants, the less likely they are to undertake control of elephants. Their loss after compensation from elephant damage is lowered and so the after-compensation loss-avoided curve in Figure 2 tends to be lower. However, in this case, the moral hazard problem is not a problem as it is socially beneficial to have less control of elephants by farmers. Elephants in Sri Lanka need to utilize some of farmers' crops to survive as a species.[83] Nevertheless, an asymmetry of information problem remains. Institutions paying compensation have less knowledge of actual damage caused by elephants on a farm than does the farmer. This adds to monitoring and agency costs generally.[84]

V. CONCLUDING REMARKS

The status of the wild elephant as a pest or an asset is quite debatable. However, it is evident that this species of wildlife causes considerable economic losses to farmers in Sri Lanka, as well as elsewhere in Asian and African elephant ranges. Elephants often extend their range into human settlements to feed on a wide variety of cultivated food and cash crops, sometimes damaging food stores, water installations, or fences and barriers, and occasionally injuring or killing people. Consequently, many farmers consider the elephant as a dangerous pest, similar to any other pests that disturb their crop production, farming practices, and social well-being. Thus, the individual farmer's decision to control elephants as a pest is purely economic and does not significantly differ from their decision to control any other ordinary agricultural pests. Under current conditions, most local farmers in the vicinity of nature reserves would eliminate elephants from their environment if they could.

This negative attitude of the farmers toward the elephant is an unfavourable portent for the future survival of elephants in Sri Lanka. Therefore, conservationists and the government must find ways to raise farmers' tolerance of elephants and their presence in farming fields. This requires a better understanding of the status of elephants as an agricultural

83. Bandara & Tisdell, *supra* note 7, at 195.

84. *See cf.* R.G. Chambers & J. Quiggin, Uncertainty, Production, Choice, and Agency 142 (2000).

pest and must take into account the farmers' perspective on the elephant. This perspective needs to be balanced against the views and interests of the non-farming communities who consider the elephant as a valued resource. However, as the damages inflicted on farmers by raiding elephants increase, farmers have become more hostile to laws that attempt to limit their damages to elephants. They can be expected to flout such laws increasingly. Even now farmers often use illegal activities, such as shooting or poisoning of elephants, to defend their crops. The use of adverse measures by farmers to control the elephant pest has eliminated elephants from much of their natural habitat in Sri Lanka, has interfered with their population dynamics, and is in conflict with the interests of non-farming communities in the society. Prohibition on the destruction of elephants has, on the whole, been ineffective in conserving Sri Lanka's population of elephants.

Our preliminary analysis revealed that elephants were responsible for about Rupees 12,049 ($128) worth of crop and property damage on average per farmer/per cropping season during the last five years in the study area. This is equal to a little over one-third of a farmer's earnings in a given cropping season. In addition, most farmers (about 70 percent) in this area spend a considerable portion of their income on crop protection activities. Some farmers plant less valuable crops, such as cassava and sweet potatoes, as borders to their farming fields to reduce the risk of damage to high-value crops such as rice and green chilli. Other farmers plant or harvest crops at non-optimal times to reduce the risk of losing all in one night of crop raiding. Moreover, in high conflict areas, most farmers have abandoned good cropland because of the sheer futility of raising a crop to maturity in the presence of elephants. Other farmers in these areas cultivate crops that are disliked by elephants even though they yield a lower income. When all these types of economic costs are taken into account, poor farmers in elephant raiding areas suffer large economic costs in relation to their income.

The level of compensation for the damage caused by the elephant in Sri Lanka is far from adequate. In most cases, it covers less than 10 percent of the actual damage caused. As a result, affected farmers often seek credit facilities and other outside supports such as the government poverty elevation benefits to meet their family requirements. Gunathilaka et al.[85] examined the level of credit burden of the subsistence farmers in the northwestern province where the fieldwork of this case study was undertaken. This analysis found that the level of credit burden of a farming family in this area ranged from Rupees 10,000 ($106.40) to Rupees 50,000

85. *See generally* Godfrey Gunatilleke et al., *Poverty and Access to Land Resources, in Rural Poverty, in* DEVELOPING ASIA 433 (M.G. Quibria ed., 1994).

($532) on average for the five years from 1987 to 1993. Such high accumulation of credits is often attributed to the higher interest rates charged by the local moneylenders, a low rate of credit repayments by farmers, unpredictable crop losses, and a low level of income. Elephants contribute significantly to unpredictable crop losses in this region. Kulathunga[86] examines the social impact of the elephant-related deaths in a sociological study of human-elephant conflict in southern Sri Lanka. This study identifies the type of families that suffer severe economic and social deprivation when they experience a death caused by elephants.

To conclude, it is found that elephant raids inflict severe economic losses on many farmers in Sri Lanka and legal prohibitions on the killing of elephants are ineffective in ensuring conservation of elephants. In our view, the long-term survival of the wild elephants in Sri Lanka depends on the development of a scheme to compensate farmers adequately for the damages they suffer as a result of raids by elephants. While farmers who are subject to the risk of damage could contribute some of the funds for such a scheme, a case exists for the bulk of the funds to be provided by non-farmers (and farmers not subject to the elephant pest problem) who consider the elephant to be a valuable resource. Such action is especially needed because the resources available to elephants in protected areas in Sri Lanka cannot on their own support sufficiently large elephant populations to ensure the long-term survival of the Asian elephant in Sri Lanka.[87]

86. P.D.R. Kulathunga, Sociological Study on Human-Elephant Conflict in Southern Sri Lanka (1999) (unpublished report in Sinhales language, Open University of Sri Lanka, Colombo, Sri Lanka) (on file with authors).

87. Bandara & Tisdell, *supra* note 7, at 195.