Economic incentives and poaching of the one-horned Indian rhinoceros in Nepal

Poaching of the One-horned Indian Rhinoceros in the Chitwan Valley, Nepal – A Retrospective Econometric Analysis

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Abstract

Despite a relatively successful conservation programme for the endangered one-horned rhinoceros in the National Parks of the Terai region, poaching remains one of the major threats to its survival in Nepal. In recent years, there has been an alarming rise in the number of rhinos poached; over 100 rhinos were taken in and around the Royal Chitwan National Park (RCNP) between 1998 and 2003. Although rhino poaching levels are influenced by the price of rhino horn on the international black market (amongst a host of other socio-economic factors), there have not been any attempts to study the reasons behind poaching in Nepal using econometric models developed and applied elsewhere. This study uses econometric models to explain changes in the level of poaching in the RCNP over a 30-year period. Factors that are thought to influence the number of rhinos poached in the RCNP include: (i) rhino population; (ii) effectiveness of anti-poaching measures; (iii) penalties for poaching; (iv) availability of alternative economic opportunities (i.e., opportunity costs of poaching); and (v) the price of rhino horn. The results indicate that anti-poaching units (APUs), in their original organisational and operational form were highly successful in controlling the level of poaching in the RCNP. Furthermore, the availability of local economic opportunities seemed to reduce the level of poaching significantly. However, the penalties imposed on the convicted poachers were found to have little or no effect on the level of rhino poaching in the RCNP. The results also indicate a sharp rise in the number of rhinos poached during the years of the Maoist insurgency in the country, compared to the years before. Although the analysis is still very simplistic, it provides valuable insights into the factors that have affected the level of poaching in the RCNP over the years. It is hoped that these insights will be helpful in formulating effective policies to tackle rhino poaching, especially in and around the RCNP where Nepal's largest population of one-horned rhinoceros is found.

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1. Introduction

Wildlife conservation has been one of the most heavily budgeted natural resource management programmes in Nepal since the late 1970s. This is especially true for the one-horned Indian rhinoceros, which is protected within the national parks in the low-lying Terai region of the south. Established in 1973, the Royal Chitwan National Park (RCNP) in the Chitwan Valley provides a habitat for most of the rhinoceros in Nepal, and the preservation of rhinos in this park is considered one of the greatest conservation success stories (Martin and Vigne, 1996). The park held less that 200 rhinos in 1973, and according to the 2000 census, the rhino population in the RCNP reached 544 in that year. Since the early 1980s, some of the rhinoceros from the RCNP have been regularly translocated to the Royal Bardia National Park (RBNP) to create a second viable population. According to the rhino census of 2000, the RBNP holds 67 rhinos (DNPWC 2001, 2002). Despite the overall success of Nepal's rhino conservation programme, a considerable number of rhinoceros have been poached both within and outside these parks since their establishment. The year 1992 is considered one of the worst in this respect: 18 rhinos were killed in and around the RCNP from a population of less than 500. Moreover, recent years have seen an even more alarming rise in the number of rhinos poached; latest figures indicate 37 rhinoceros were poached in and around the RCNP in the year 2002 alone (Figure 1).

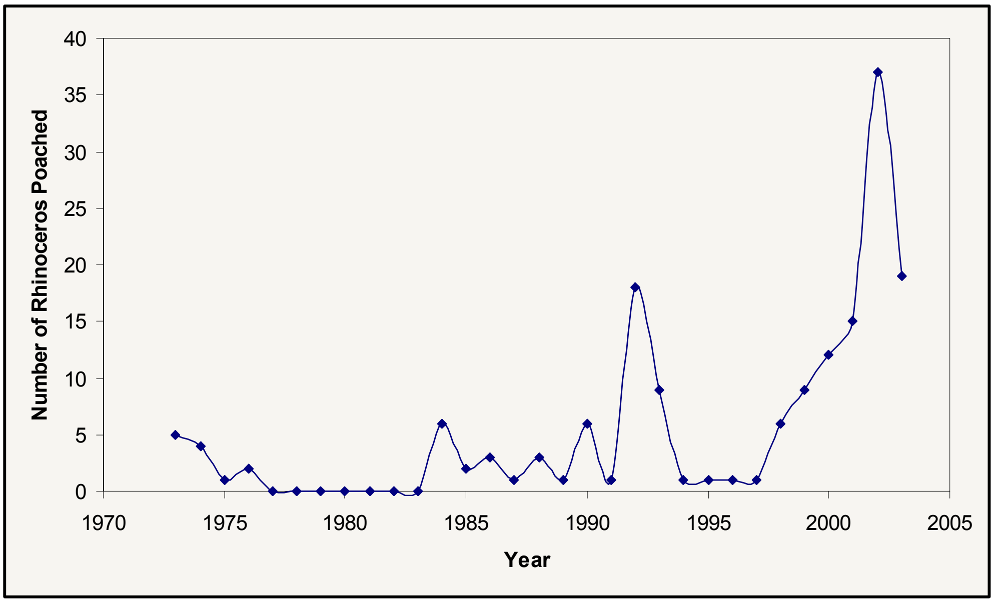

Figure 1 *Number of one-horned Indian rhinoceros poached in the Chitwan Valley from 1973 – 2003.*

Over the last decades, there have been a number of policy changes to combat the loss of endangered species like rhino. For example, stronger enforcement techniques have been put in place, such as the introduction of Royal Nepalese Army (RNA) to protect the rhinos and other endangered species within the national parks. The main conservation policy and wildlife management option in Nepal has always been the legal protection of wildlife within (and outside) the parks, and the use of penalties for those who infringe those laws. However, these policies only seem to work for a short period of time before poaching increases again. Although rhino poaching levels are influenced by the price of rhino horn on the international black market, there has not been an attempt to study the reasons behind poaching using econometric models that have been developed and applied elsewhere (mostly in Africa). This study is an attempt to develop and empirically test such econometric models for rhino poaching in the Nepalese context.

The organisation of the paper is as follows. Section 2 presents a brief overview of theoretical and empirical work previously undertaken on poaching in general, and on rhino poaching in particular. Conceptual and structural/analytical models for this analysis are then presented in Section 3. Section 4 describes the data requirements, availability and collection, and the methods for analysis. The results of the analysis are presented in Section 5. Finally discussion on the results and their policy implications are presented in Section 6.

2. Analysis of Poaching: A Review

There have been a number of studies on the illegal exploitation of African rhinos and elephants, most notably those in the Luangwa Valley in Zambia (for example, Leader-Williams, Albon and Berry, 1990; Milner-Gulland and Leader-Williams, 1992a; Leader-Williams and Milner-Gulland, 1993). Although these studies are focussed more on the relationship between illegal exploitation and anti-poaching law enforcement, they have attempted to look at socioeconomic factors affecting the level of poaching (such as alternative economic opportunities). The study by Leader-Williams et al. (1990) concluded that the declines in rhino numbers occur due to problems originating outside the protected areas, such as the increasing price of rhino horn on the international market and a decline in other economic opportunities for local people living in and around the protected areas. The international ivory trade has also been blamed for the decline in the African elephant population (Pilgram and Western, 1986). Leader-Williams et al. (1990) report that "law enforcement units were effective in capturing poachers, but were too small to provide protection to large populations of rhino and elephant". They estimated an optimal rate of one man per 20 km2 for effective law enforcement in the protected area.

Milner-Gulland and Leader-Williams (1992a) modelled the poaching in the Luangwa Valley by local poacher and by dealer, with respect to the financial gains, detection and penalties. They report that a penalty that varies with the output of a poacher is more effective than a fixed penalty. More importantly, the detection rate was found to be more of a deterrent for poachers than the penalty. Furthermore, they report that different incentive structures attract local poachers and dealers to poaching, and hence any policy to curb poaching by a local poacher might not stop poaching by organised gangs employed by the dealer. It is worth noting that Milner-Gulland and Leader-Williams (1993) depict the dealers as the resource controllers in their model, implying that they focus on long term profit maximisation from wildlife exploitation. This assumption, however, seems unlikely in the case of national parks such as the RCNP in Nepal, where the resource controller is obviously the park authority (or the state) who is in charge of managing the parks. There are important distinctions between the dealer and the park authority as resource controllers. Firstly, the dealers' action is illegal and thus liable to a penalty, which must be considered in modelling their net returns from poaching. Unlike dealers, park authorities bear an extra cost of law enforcement. More importantly, in the context of the RCNP, the resource controller (park authority) does not maximize net benefits by harvesting rhino, as the national park's economic benefit comes mainly from tourism.

Skonhoft and Solstad (1996, 1998) develop a more general model of wildlife exploitation. Their model is similar to that developed by Milner-Gulland and Leader-Williams (1992a) in that it explicitly models the exploitation of wildlife by local poachers. However, there is a fundamental difference – rather than setting the dealers as the resource controllers, they model an agency managing the park in this role, which is more realistic (see above). Their model is a two agent (local poachers and park authority) model where each agent maximizes its net benefits given constraints and the other agent's actions. The variables, such as wildlife numbers and the degree of law enforcement effort, enter the benefits function of both the agents, with differing impact. Similar to Milner-Gulland and Leader-Williams, Skonhoft and Solstad model the resource controller (the park authority in this case) as a long term profit maximiser. However, there is still a fundamental difference between these two resource controllers. The park authority holds the property rights of the park, whereas the dealers do not. This distinction applies to local poachers as well. In this respect, Skonhoft and Solstad analyze the outcome of the agents' actions under different property rights structures.

In a similar but more empirical study, Bulte and van Kooten (1999) constructed a model to analyse the effects of the ivory trade ban on poaching and elephant stocks in Africa. They used data from Zambia to parameterize their model, and showed that banning trade may increase or decrease equilibrium elephant stocks. While the models of Skonhoft and Solstad (1996, 1998) are based on utility maximization at the household level (agricultural household model), Bulte and van Kooten (1999) use a simpler open access formulation that is more amenable to empirical application. A more recent study on poaching of tigers and their prey in India by Damania et al. (2003) combine utility maximization at the household level. They do this through a household model that explains poaching behaviour of farmers and poachers using tiger population growth to determine time paths of tiger stocks under alternative scenarios. They suggest that increasing the opportunity costs of poaching might be a potentially effective way to reduce poaching.

3. The model

3.1 Conceptual Model

The conceptual model builds on the factors that are hypothesised to influence the decision to poach (and subsequent levels of poaching) by the local poachers. Studies on the incentives (or disincentives) to get involved in illegal activities have suggested that a rise in (i) the probability of punishment or stricter punishment, (ii) a fall in profits from an illegal activity, or (iii) a higher opportunity cost of an illegal activity due to economic opportunities elsewhere, all help reduce the level of illegal activities (Cook, 1977 cited in Milner-Gulland and Leader-Williams, 1992a). Rhino poaching, being an illegal activity, can be studied under a similar incentives (or disincentives) structure. We build our conceptual model (Figure 2) based on this structure, which looks into (i) effectiveness of anti-poaching measures that determines "the probability of being caught and convicted",

(ii) penalties (fines and prison sentences) when caught poaching, (iii) available economic alternatives (i.e., the opportunity cost of poaching), (iv) the cost of poaching (direct costs of poaching that determines the level of profits), and (v) the price of rhino horn on the international (black) markets (often the biggest motivator for poaching). We look at each of these factors in detail.

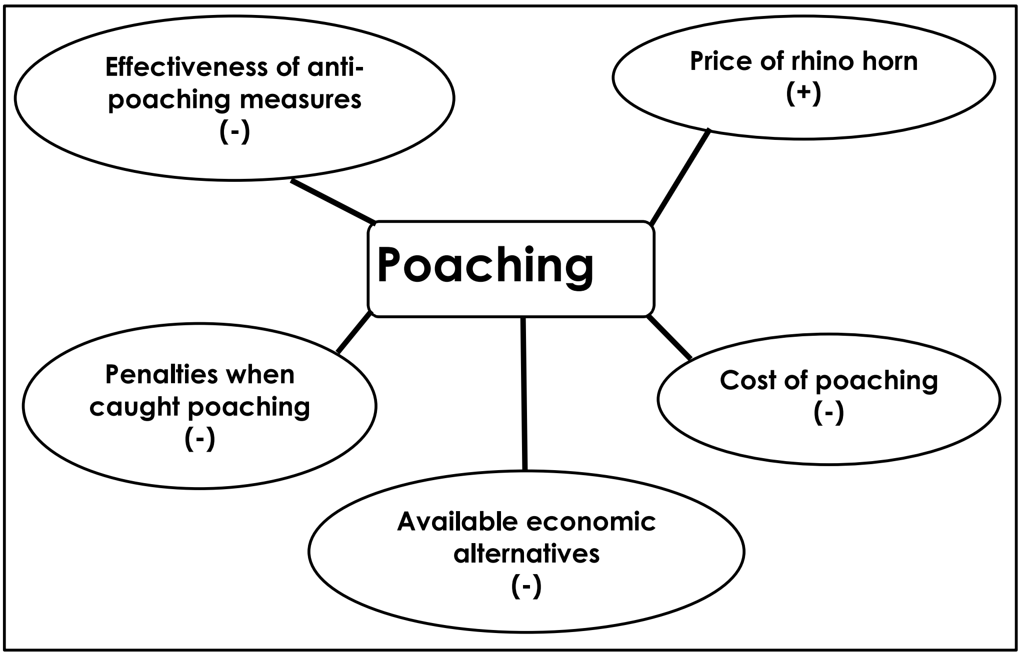

Figure 2 Factors that affect poaching by local poachers in Terai.

(i) Effectiveness of anti-poaching measures

It is intuitive that poachers adjust their behaviour and decisions to account for the likelihood of their detection and capture. This likelihood, in large part, depends upon the level and effectiveness of the anti-poaching measures in place. A number of studies have looked into the effect of the level of law enforcement and its effectiveness on the poaching of wildlife, mostly notably in African contexts (for example, Leader-Williams and Milner-Gulland, 1993; Leader-Williams, Albon and Berry, 1990; Milner-Gulland and Leader-Williams, 1992a; Jachmann and Billiouw, 1997; Yi-Ming et al., 2000). Leader-Williams et al. (1990), in their study on poaching of black rhinoceros and elephants in the Luangwa Valley (Zambia) found that an increased patrol effort reduced illegal activity within the protected area, which in turn reduced the decline in rhino and elephant populations. Milner-Gulland and Leader-Williams (1992a, 1993) confirm this proposition in their subsequent studies at the same site. They have suggested that the probability of detection – a direct result of the enforcement effort and its effectiveness – could be a better deterrent than the penalty imposed on poachers when caught (the issue of penalties is discussed in (ii)). A more recent study on elephant poaching, also in the Luangwa Valley, looked at resources allocated to enforcement in terms of manpower, budget, rewards etc. The study concludes that success in elephant conservation is due to increased levels of enforcement (i.e., manpower and budget), and also due to effectiveness in enforcement (through the introduction of specific investigation operations, and the bonus system) (Jachmann and Billiouw, 1997). A similar study by Yi-Ming et al. (2000) on illegal wildlife trade in the Himalayan region of China found that the poaching and smuggling of wildlife in this region did not show a significant reduction after the introduction of a stricter wildlife protection law, mainly due to lack of effective enforcement. The studies on rhino conservation in Nepal have reported findings along the same lines (for example, Martin and Vigne, 1996; Martin, 1996; Dhakal, 2002; Adhikari, 2002; Yonzon, 2002). It is reported that increases in level of enforcement (through the introduction of APUs) and increases in effectiveness of enforcement (through increased patrols and use of intelligence networks) have reduced poaching significantly over the years. Moreover, a lack of these measures has resulted in higher levels of poaching in certain 'in-between' years, and more so in the years after 1998 (ibid). Yonzon (2002) further points out that the ongoing Maoist insurgency has affected the level and effectiveness of the enforcement, thereby increasing the level of poaching.

The effect of enforcement on the level of poaching seems to be well established, however, most of these studies have failed to look into how poachers react to these changes in enforcement, and whether they adapt to these changes by becoming more effective hunters themselves, or just opt out of poaching and find other sources of income. There is evidence that the effectiveness of anti-poaching enforcement in Nepal is affected by the knowledge that poachers possess of the enforcement techniques that are used (Gurung and Guragain, 2000). The study further points out that poaching increased in the Terai region as poachers became familiar with the anti-poaching efforts and adapted to the techniques used by enforcement personnel (ibid, p. 5). By knowing what the enforcement officers would do, how they would do it and when they would be at a given location, poachers could increase their poaching success. Moreover, this knowledge is liable to increase over time for a given set of enforcement arrangements. For example, the initial success of new anti-poaching activities from 1977-1983, and before 1992, was followed by increases in poaching in 1984 and 1992. A further change in enforcement in 1993 subsequently halted poaching for a number of years before it picked up again in 1998 (Adhikari, 2002). So, it is essential to look not only at the level of enforcement and its effectiveness for a given year, but also how this effectiveness changes over the years due to changes in poachers' hunting patterns, and also due to other external factors (such as the Maoist insurgency).

(ii) Penalties when caught poaching

Another factor affecting the level of poaching is the penalties that poachers face when captured and convicted. Penalties could either be fines, prison sentences or a combination of both; confiscation of trophies is often considered additional to the penalties faced by the poachers. As with the probability of detection, a penalty also increases the expected cost of poaching, and hence it should, theoretically, reduce a (rational) poacher's incentive to poach. However, the opinions, as well as results, seem to be mixed in this regard (see for example, Leader-Williams, Albon and Berry, 1990; Milner-Gulland and Leader-Williams, 1992a, 1992b; Leader-Williams and Milner-Gulland, 1993; Clarke, Reed and Shrestha, 1993). This mixture of opinions and results could, to a large extent, be attributed to the complex nature of the penalty itself. Since the penalty not only constitutes monetary fines (and confiscation of trophies) but also prison sentences, administering a penalty that comprises a fine or a prison sentence (or a mixture of both) has a very different effect on a poacher's behaviour (Milner-Gulland and Leader-Williams, 1992a; Leader-Williams and Milner-Gulland, 1993; Clarke, Reed and Shrestha, 1993).

Clarke et al. (1993) looked into a penalty structure that only constitutes fines, in their study of illegal logging in developing country forests. They point out that while higher fines might have a deterrent effect when poachers make decisions about whether to poach or not, the level of poaching itself depends on the marginal net benefits from poaching, and hence on the marginal fines. Thus, contrary to expectations, higher fines may induce poachers to poach at a higher level to offset the greater fines they face in the event of their capture and conviction (ibid, p. 284). Leader-Williams and Milner-Gulland (1993) state that due to poverty, fines are likely to deter local poachers from poaching elephants and rhinos; however, they also agree that too high a penalty could exacerbate poaching instead of reducing it. A penalty that only constitutes a prison sentence provides a different incentive (or disincentive) structure to the poachers. In the case of a prison sentence, the deterrence effect on the poachers depends upon their discount rate and time horizon i.e., how much they value the present over the future and how far into the future they look when making decisions (Leader-Williams and Milner-Gulland, 1993). Assuming poachers have a sufficiently low discount rate and higher time horizon, they will be more hesitant to poach wildlife and risk capture and conviction when the penalties for doing so are higher (i.e., when they are likely to be in prison for a long time). Leader-Williams and Milner-Gulland (1993) point out that in Africa, the future is very uncertain so poachers are less likely to have a longer time horizon or a lower discount rate. This, in turn, suggests that the severity of prison sentences might not deter poachers from poaching. They further state that focussing on increasing detection rates could be a better strategy in these countries, rather than increasing the severity of prison sentences (p. 613). Similar strategies could be argued for many other developing countries (including Nepal) as they face similar political and economic problems.

However, in contrast to the two scenarios above, the real penalty structures governing wildlife conservation in most countries are a mixture of prison sentences and fines. Thus, characteristics of both these penalties come into play, which determines the behaviour of poachers. One of the major issues raised regarding this mixed penalty is that of the conversion rate between prison and fines (Milner-Gulland and Leader-Williams, 1992a). Milner-Gulland and Leader-Williams (1992a) point out that standard methods of conversion (using loss of earnings when in prison) fail to take into account other factors associated with a prison sentence, for example, the difficulty in getting a job with a criminal record. Furthermore, standard conversion tends to imply that a prison sentence is more severe for the rich than for the poor, given higher loss from the foregone earnings of the rich. However, it has been argued that a prison sentence is usually more severe for the poor local poachers as it has serious effects on their families' welfare. This is because these poachers are, in most cases, the sole provider of family income (Leader-Williams and Milner-Gulland, 1993). As such, in their study of poaching incentives, Milner-Gulland and Leader-Williams (1992a) use magistrates' perception of the conversion rate between prison and fines when sentencing poachers. They justify their choice by arguing that “a person's perception of the penalty must be better than a wage-based conversion, even if that person is a judge” (p. 390). Another issue lies with the relative severity of each component in the prison-fine penalty structure and in devising an optimal combination. Milner-Gulland and Leader-Williams (1992a) point out that if the prison sentence is less severe than the fine, then many poachers would simply choose prison instead, which increases expenses to the state. On the other hand, a less severe fine could encourage dealers and middlemen to buy acquittal of the hunters they hired for poaching, as dealers and middlemen are usually not convicted themselves (Leader-Williams and Milner-Gulland, 1993; Gurung and Guragain, 2000).

In reality, most countries have been increasing the severity of penalties over the years – both in terms of higher fines and longer prison sentences (Leader-Williams and Milner-Gulland, 1993; Maskey, 1998). However, Leader-Williams and Milner-Gulland (1993) caution against setting too high a fine, as dealers are likely to let their hired hunters go to prison by default instead of buying their acquittal, and hire new hunters for further poaching. They suggest that a more appropriate solution would be to sentence dealers themselves (p. 615). Nevertheless, severe penalties mean that poachers must be paid more in order to persuade them to risk being captured; this means dealers and middlemen hiring these poachers are likely to be deterred. Furthermore, Milner-Gulland and Leader-Williams (1992a) have shown that a penalty that varies with poachers' output (e.g., number of horns) is a more effective deterrent than a fixed penalty. The level of penalties, however, depends on the magistrates or judges who administer the sentences to the convicted poachers, and on many occasions they were found to misinterpret their own country's wildlife laws (Leader-Williams, Albon and Berry, 1990). The case of Nepal seems even more serious. Gurung and Guragain (2000) point out a number of cases where sentences have been influenced, and poachers released without serving the entire sentence, due to pressure from the political elite (pp. 14-15). Nevertheless, the severe penalty structure in place in Nepal for wildlife offences since 1993 is reported to have significantly deterred poachers (Martin, 1998). Although the likely deterrent effect of a severe penalty is acknowledged, scholars seem to agree that a higher probability of detection is more of a deterrent than a higher penalty (Milner-Gulland and Leader-Williams, 1992a, 1992b; Leader-Williams and Milner-Gulland, 1993; Clarke, Reed and Shrestha, 1993).

(iii) Available economic alternatives

Poaching at the local level is essentially an economic phenomenon, and hence the availability of alternative economic opportunities locally plays an important role in determining the incentives for poaching. If alternative pursuits offer a higher rate of return, then the opportunity cost of poaching increases and the incentive to poach declines. A number of studies have reported the success of local investment schemes initiated by wildlife conservation authorities in partnership with local bodies. These programs reduce the level of illegal activities (such as poaching) by increasing the opportunity cost of such activities (for example, Milner-Gulland and Leader-Williams, 1992a; Leader-Williams and Milner-Gulland, 1993; Martin and Vigne, 1996; Martin, 1998). Milner-Gulland and Leader-Williams (1992a, 1993) point out that projects that i) return some of the revenues from safari hunting and tourism to the local community, ii) ensure local participation in management decisions, and iii) create jobs locally have all been very successful in reducing poaching in many parts of Africa. Furthermore, a higher opportunity cost from the availability of alternative economic opportunities means that the dealers and middlemen who hire local poachers must pay more in order to make poachers take on a risky job. This makes poaching more costly.

Martin and Vigne (1996) report that the growing tourism sector in and around the RCNP has been providing an increasing number of jobs to the locals. Increases in the opportunities locally are likely to deter poachers/would-be poachers from taking up poaching. Martin (1998) provides examples of a number of community development schemes initiated by the government, and non-government organisations in and around the RCNP and the RBNP in Nepal, which have been helping improve skills of the locals, create employment opportunities locally, and raise overall economic opportunities that has helped protect wildlife, such as rhinos within those parks. Furthermore, he points out that the new buffer zone management scheme, which provides half the revenue of the park to the local community, could have a significant impact on creating projects that increase economic opportunities locally, especially around a park like the RCNP, which generates substantial revenue from tourism. Moreover, potential for eco-tourism initiatives within the community forest of the RCNP buffer zone (as demonstrated by the case of Baghmara Community Forest) could create sufficient economic incentives to deter locals from poaching. Thus, in general, it is justifiable to assume that greater availability of alternative economic opportunities locally will deter local poachers and would-be poachers from being involved in poaching. It should be noted, however, as Milner-Gulland and Leader-Williams (1992a) point out, that organised gangs, middlemen, and poachers who are not locals are not directly deterred by such local economic alternatives. As such, local alternatives would not affect their opportunity costs.

(iv) Cost of poaching

The (direct) financial costs of poaching are defined as the wages (labour) and equipment (capital) that are required for a poaching expedition, as well as the ease of finding and killing the animals. Generally, it is assumed that as the cost of poaching increases, the incentives to poach will decrease and vice-versa, all else being equal. A number of issues emerge when analysing the effect of the cost of poaching on poaching incentives as per this assumption. Firstly, a major issue relates to the types of poachers and differential costs they face when organising a poaching expedition. A general observation in the previous studies has been that the local poachers generally face low costs for a poaching expedition compared to an organised gang member, mainly due to the sophistication of the equipment (e.g., weapons, communication equipment) used (for example, Milner-Gulland and Leader-Williams, 1992a; Leader-Williams and Milner-Gulland, 1993). However, it is important to note that a local hunter in the Chitwan Valley, Nepal, whether acting himself or hired to poach a rhino, faces very low costs either way. If he is acting himself, his cost is low due to the primitive technology used, such as digging pits, poisoning and using home-made firearms; on the other hand, if he is hired by a dealer or an organised gang, all the equipment used will be provided by his employers which keeps his costs low. Moreover, previous studies have shown that the most common method to kill a rhino in the Chitwan Valley is pit digging , followed by spearing, snaring, and poisoning (Martin and Vigne, 1996; Chungyalpa, 1998; Maskey, 1998; Gurung and Guragain, 2000). Nevertheless, more firearms are reported to have been used recently (Martin, 2001). Gurung and Guragain (2000) point out that the community forests and farms within the park buffer zone are the areas where poaching occurs frequently. In recent years, due to a healthy rhino population in the RCNP, more rhinos are found to wander out into the community forests or farms (Dhakal, 2002), suggesting that it is relatively easy for a poacher to find a rhino. This lowers the search effort and hence the cost. On the other hand, poachers are also found to target the areas with high rhino concentration (Gurung and Guragain, 2000), which of course leads to a lower cost in terms of search efforts. Thus, although high costs of poaching could be a definite deterrent for poachers, the fact remains, in the case of rhino poaching in the Chitwan Valley, that poaching costs for local poachers have remained low historically and continue to do so. This also suggests that, for the local poachers in the Chitwan Valley, opportunity costs could be more of a deterrent than the direct financial cost of poaching.

(v) Price of rhino horn

The price of rhino horn on the international black market directly affects the profitability of poaching. An obvious assumption would be that an increase in the price of rhino horn increases the incentives to poach. Studies on rhino poaching have shown that middlemen, dealers, and international traders are the groups that profit the most from a high price of rhino horn on international markets, with the actual hunters getting relatively low prices for their efforts in comparison (for example, Martin and Vigne, 1996; Menon, 1996; Maskey, 1998; Gurung and Guragain, 2000; Martin, 2001). However, it is often the case that the low price obtained by poachers is well above their average earnings at local wage rates (Chungyalpa, 1998). Indeed, previous studies have all suggested that one of the main reasons local hunters get into rhino poaching is their abject poverty. The price they receive for poaching a rhino (which is often more than their entire year's earning from other sources) becomes much more lucrative and hence, provides real incentives to poach (for example, Maskey, 1998; Gurung and Guragain, 2000).

The price of Asian rhinoceros horn (e.g., from the one-horned Indian rhinoceros) has historically been very high on the international market, in comparison to that of African horn . Leader-Williams (1992) reports increasing demand for rhino horns, and the growing (illegal) trade in rhino horn and products derived from it to be "largely responsible for reducing rhinos to their presently endangered status." This growing demand for horn on the international market (which in turn increases the price) is likely to increase the price received by poachers at the local level. This subsequently increases the incentives to poach.

In fact, a simple analysis of the retail price of Asian rhino horn (reported in earlier studies) and the share of profits that go to local poachers, highlights the incentives to poach. The local poachers are reported to receive about 1% of the final profit from the horn trade (Chungyalpa, 1998), and the retail price of Asian rhino horn has been reported to be US$ 40,000 – 60,000 at the higher end (Nowell, Chyi and Pei, 1992). This shows that even 1% of the profit could be highly attractive to a poor hunter in Nepal, where per capita income is less than US$ 250, and 42% of the population live in poverty . The actual price received by a local hunter for poaching a rhinoceros is not reported in most of the earlier studies except in Gurung and Guragain (2000), who report that a local hunter in Nepal is paid approximately US$ 150 for poaching a rhino (p.18) . The authors confirm that the growing value of rhino horn on international markets is one of the important reasons behind rhino poaching (ibid, p. 18).

3.2 Structural/Analytical Model

A review of the factors considered in the literature to influence the level of poaching forms the basis for our structural/analytical model. The objective here is to derive a reduced-form poaching function that captures the incentives structure as outlined above, and test this model empirically using the available data for rhinoceros in the RCNP. A number of works reviewed above (Section 2) have tried to model poaching under different assumptions. However, these studies are mostly focussed on African contexts; the poaching structure in Nepal differs significantly from that of African countries. Firstly, although the hunters are mainly locals in Nepal, poaching is largely controlled by relatively few dealers based in major cities like Kathmandu and Pokhara (Gurung and Guragain, 2000; Martin, 2001). Furthermore, these local hunters are very poor and landless, with few alternative opportunities (Maskey, 1998; Gurung and Guragain, 2000), which suggests that an optimisation framework involving labour allocation between farming and poaching at the household level is unsuitable in the Nepalese context.

Although the management of rhinos is under a state property rights regime, we assume that poachers act as if there is de facto open access governing their industry, since they operate outside legal property rights. A simple model for poaching industry profits under open access and the threat of capture and conviction might be:

$$\pi t = pt\ h(Bt, Et, Xt) - \theta(Bt, Et)(Ft + pt.h) - c(At, Et) \tag{1}$$

where π is poaching profits; p is the gross price per poached animal product; h(B,E,X) is the poaching harvest function; B is the enforcement effort; E is poaching effort; X is the stock of the poached animal; θ(B,E) is the probability of capture/conviction, expressed as a function of poaching effort and anti-poaching enforcement effort; F is the fine upon conviction and/or proxy for the value of time, if incarcerated; and c(A,E) is the poaching cost function, expressed as a function of alternative economic opportunities, A, and poaching effort, E. Note that if captured, the poacher must pay the fine plus forego the benefits of the animal product in his possession.

If open access profits are assumed to be zero in each time period (as a result of free entry and exit) then the short run equilibrium level of effort (Et*) can be derived for each time period from equation (1). Given a set of parameters and observations on the variables in (1), we get:

$$Et^* = f(Bt, Xt, At, Ft, pt) \tag{2}$$

Equation (2) defines poaching effort in terms of anti-poaching effort, B; stock size, X; opportunity costs of poaching, A; fines imposed on poachers when captured and convicted, F; and price of the rhino horn, p. Since data on the level of poaching effort, E, is extremely difficult to obtain, we can substitute equation (2) back into the harvest function h(B,E,X) to obtain a reduced-form statement for annual poaching output (h*) as follows:

$$h^*t = h^*(Et^*, Bt, Xt) = h^*(f^*(Bt, Xt, At, Ft, pt), Bt, Xt) = h^*(Bt, Xt, At, Ft, pt) \tag{3}$$

It is possible to estimate (3) if sufficient data are available for all of the variables, as either an ad hoc model or by deriving a fully specified model from the general functions in (1). The above approach is just representative of many such approaches that could be taken to model the poaching problem. Nonetheless, the variables captured in the model cover the key economic determinants of poaching as hypothesised earlier, thereby allowing modelling of alternative policies for their impact on poaching. Given the time constraints, we estimate an ad hoc model for the purpose of this study. The following section discusses data availability and collection issues, and the model estimation.

4. Data and Analysis

4.1 Data Requirements and Availability

The primary data required for the analysis of the reduced form poaching function is the number of rhinoceros poached each for the period specified. The number of rhinos poached each year has been very well recorded since the establishment of the RCNP, and was easily available from various previous studies (Martin and Vigne, 1996; Maskey, 1998; Dhakal, 2002 among others), and from DNPWC Annual Reports. Other than the number of rhinoceros poached, an empirical estimation of the reduced form poaching function specified above requires data on (i) the stock size (i.e., rhino population), X, (ii) anti-poaching effort, B, (iii) opportunity costs of poaching, A, (iv) fines imposed on poachers when captured and convicted, F, and (v) the price of rhino horn, p.

Stock size, *X*

The data on Nepal's rhino population is highly discontinuous, for there have only been a couple of official censuses to determine the population, and demographic structure of the one-horned rhinoceros. Most of the earlier figures on population come from individual studies (for example, Laurie, 1978) and tentative estimates. The first official census was carried out in 1994 and the second in 2000. The data on the rhino population in the RCNP from all available sources were compiled, cross-checked and verified. The annual rhino population over the years was then estimated by using a discrete stage-class population model (Rothley, Knowler and Poudyal, 2004). This estimated population is used for modelling the reduced form poaching function. Since the population estimated by Rothley *et al.* (2004) provides end of the year estimates, we use the lag of this variable in our regression equation (which equals the start of the year estimate for the following year). This allows us to capture the exploitable stock size for a given year. This variable is expected to have a positive effect on poaching, as a higher population allows the poachers to find and kill rhinos with less effort.

Anti-poaching effort, *B*

It is very difficult to actually measure anti-poaching efforts in the RCNP and within the Chitwan Valley, due to various anti-poaching structures in place inside and outside the park. For example, the RNA only patrol inside the park, whereas APUs patrol both inside and outside the park, and forest guards patrol in the adjoining forests. Moreover, the recorded information on anti-poaching efforts is almost non-existent. The information on the number of RNA staff stationed within the park and their patrolling efforts was unavailable due to security reasons (given the highly unstable and sensitive political situation in the country in recent years). The only information on anti-poaching available through DNPWC Annual Reports and WWF reports was on the number of APUs active within the Chitwan Valley since they were established in 1993. The RNA has been stationed in the park since 1975, so using a dummy for that variable would not make sense: there would be only 2 previous years when it would be zero. Thus the number of APUs active during a year is used to capture anti-poaching effort within the RCNP and in the Chitwan Valley in general. This variable is expected to have a negative effect on poaching, as it has a deterrent effect on poachers.

Opportunity costs of poaching, *A*

The opportunity costs of poaching for a region could be captured by using an economic indicator for that region, such as per capita GDP in that region. However, there was no long term data available for regional economic indicators of such kind. Since the socio-economic structure of the Chitwan Valley very much mirrors the national socio-economic structure, we decided to use the national per capita GDP to capture the opportunity costs of poaching. Furthermore, it has been reported that some of the poachers actually come from outside the Chitwan Valley, so national per capita GDP in general should be a good indicator of the opportunity costs of poaching. This variable is expected to have a negative effect on poaching, as the higher the opportunity costs of poaching, the more likely it is that poachers will be attracted to alternative economic activities rather than to poaching.

Fines imposed on poachers when captured and convicted, *F*

Over the years, there have been only two levels of fines and jail terms for convicted poachers. The current law on the penalty for convicted poachers states that the maximum penalty for a convicted poacher is 15 years in jail, a Rs 100,000 fine, or both. However, a study on earlier convictions reveals that hardly any prisoners served more than 4-5 years in jail and that judges seem to impose fines rather than prison sentences. Furthermore, most of the poachers in prison are those who could not pay the fines and/or default on them. As discussed earlier [**(ii)** in Conceptual Model section], translating prison sentences into equivalent fines is very complex. Given this complexity and the fact that fines were more frequently imposed than jail terms for convicted poachers in Nepal, we use just the fines portion of the penalties for the purpose of this analysis. The nominal fines over the years were converted to real terms before using them for the analysis. This variable is expected to have a negative effect on poaching, due to the deterrence effect penalties have on poaching.

Price of horn, *p*

Data on the international price of rhino horn is very difficult to find, mainly because this trade has been banned since the early 1970s. There have been various attempts to compile price of horns on the black market, such as by Martin (1983, 1987, 1989), Martin and Ryan (1990), and Leader-Williams (1992), but the data are too few and far between. To get around this problem, we looked at one of the major international markets of Indian rhino horn – Hong Kong. Almost all the horns from Indian rhinoceros poached in India and Nepal go to the international market via Kathmandu, and the first entry point into this market is Hong Kong. Furthermore, Hong Kong is one of the main consumers of rhino horn and horn products. We assume that as people get richer in Hong Kong, their overall demand for rhino horn and horn products increases, and hence the price goes up. Under this assumption, we use per capita GDP in Hong Kong, lagged by a year, as a proxy for the price of rhino horn. It is worth noting that Milner-Gulland (1993) used a similar approach to estimate the consumer demand for rhino horn in Japan. Instead of price, she used GNP as the explanatory variable to estimate this demand.

Some recent studies on the status of the one-horned rhinoceros and problems of poaching in Nepal have suggested that the ongoing Maoist insurgency in the country is having a negative impact on rhino conservation. A significant reduction in the number of RNA guard posts in the RCNP (due to the Maoist problem) is considered a major factor behind the high poaching levels of recent years (Yonzon, 2002; Martin, 2004). To account for this factor, we introduce a dummy variable, MAOIST, in our data, which equals 0 up to the year 1996 (when the insurgency started) and 1 from the year 1997 onwards. The codes and descriptions of the variables used in the model are presented in Table 1, and the frequency distribution and descriptive statistics for the dependent variable are presented in Table 2, and Table 3 respectively.

4.2 Analysis

The regression model for estimating the reduced form poaching function depends on the characteristics of the data at hand. The number of rhinos poached over the years (the dependent variable) is a count data ranging from 0 to 37 (Table 2), which cannot be negative; this means OLS regression is not suitable for the estimation of the reduced form poaching function. Instead, we use the Poisson regression technique, which is commonly used for count data models. The density function of a discrete random variable, Y, with a Poisson distribution is:

, $y = 0, 1, 2, \ldots$

The Poisson distribution has a single parameter u, where E[Y] = V[Y] = u. Given these characteristics of the distribution, a Poisson regression function is specified as:

, so that $\mu > 0$.

Thus, a Poisson regression is a log-linear regression model where, by assumption, the conditional mean E[yi | xi] is equal to the conditional variance V[yi | xi]. This assumption of mean being equal to variance rarely holds in practice, as can be seen from the descriptive statistics for the dependent variable POACH_NP in Table 3. The variance is more than thirteen times the mean of the variable. When the conditional variance is greater than the conditional mean, this is called "overdispersion", and it can be tested using a number of techniques. The LIMDEP econometric package automatically provides statistics for the regression-based overdispersion tests. This package was used to test for overdispersion in our regression model and to consider alternative regression models. The alternative to the Poisson regression model that relaxes the assumption of equality in mean and variance is the Negative Binomial Model. Both the Poisson and Negative Binomial models were estimated and the most suitable model was selected after i) tests for overdispersion and ii) tests for model itself against the alternative. The results are presented in the next section.

Table 1 Variables used in the estimation of reduced form poaching function.

Variable Code	Definition
Dependent Variable:	
POACH_NP	Number of rhinoceros poached during the year inside the RCNP
Independent Variables:	
POPN	The population of rhinoceros inside the RCNP at the end of the year
REAL_PEN	The penalty imposed for convicted poachers in real terms
APU	The number of anti-poaching units active during the year
GDPC_NEP	Per capita GDP of Nepal in constant 1990 prices
GDPC_HK	Per capita GDP of Hong Kong in constant 1990 prices
MAOIST	Dummy variable that equals to 0 up to year 1996 and 1 for the year 1997 onwards (to account for the effect of Maoist insurgency in poaching)

Table 2 Frequency Distribution for the number of rhinos poached inside the RCNP from 1973-2003.

Number of rhinoceros poached	Frequency	Percent	Cumulative percent
0	10	32.3	32.3
1	6	19.4	51.6
2	3	9.7	61.3
3	3	9.7	71.0
4	1	3.2	74.2
5	1	3.2	77.4
6	1	3.2	80.6
9	1	3.2	83.9
12	1	3.2	87.1
15	1	3.2	90.3
17	1	3.2	93.5
19	1	3.2	96.8
37	1	3.2	100.0
Total	31	100.0	

Table 3 Descriptive Statistics for the number of rhinos poached inside the RCNP from 1973-2003.

N	Minimum	Maximum	Mean	Std. Deviation	Variance
31	0	37	4.68	7.985	63.759

5. Results

Firstly, the reduced form model was estimated including all the explanatory variables that were thought to influence the number of rhinoceros poached in the RCNP. The results are presented in Table 4, where column 3 provides the estimation results from the full Poisson model (i.e. Poisson Model 1), and column 5 provides the estimation results from the full Negative Binomial Model (i.e. Negative Binomial Model 1). Coefficients on all the explanatory variables in the full model, except REAL_PEN, have the expected signs. The variable REAL_PEN is highly insignificant, along with the coefficient on

GDPC_HK[-1]. Overdispersion tests obtained from LIMDEP for the Poisson Model 1 (i.e., g = u(i): 1.902) indicate the presence of overdispersion in the dependent variable POACH_NP. The Negative Binomial Model 1 (column 3) was estimated to take into account the presence of overdispersion. Since the negative binomial model presented the convergence problem in estimation of LIMDEP, the overdispersion parameter, α was fixed at 0.2 to estimate the Negative Binomial Model. The results from the Negative Binomial model estimation show an overall improvement in the estimated coefficients and their significance; however, the coefficient on REAL_PEN still has the positive sign contrary to our expectations. The likelihood-ratio test for the Poisson Model 1 vs Negative Binomial Model 1 gives a Chi-squared value of 12.78 , which is higher than the critical value of 6.63 at 1% with 1 degree of freedom. Thus, the Negative Binomial Model 1 is preferred over the Poisson Model 1 (i.e., the restricted model).

As the coefficient on the variable REAL_PEN was highly insignificant in the full model, we then estimated the reduced form model without this variable. The results are shown in Table 4 – in column 4 for Poisson Model 2, and in column 6 for Negative Binomial Model 2. Although the estimated coefficients in Poisson Model 2 are not very different from the Model 1, there are signs of overdispersion in the dependent variable (g = u(i): 1.886). The coefficients on the Negative Binomial Model 2, however, offer an improvement over Model 1, with the coefficient on the variable GDPC_HK[-1] coming very close to being significant (p-value = 0.23). All other coefficients on explanatory variables stay highly significant (i.e., at 1% or less). The likelihood-ratio test again favours the Negative Binomial Model 2 over the Poisson Model 2 (Chi-square = 12.9). Overall, the Negative Binomial Model 2 provides the best estimates of the variables that are hypothesised to influence the level of poaching in the RCNP.

Figure 3 shows the observed level of poaching and the predicted values from the Negative Binomial Model 2. The predicted values follow the observed value very closely for most of the years, including the years 2002 and 2003, when 37 and 19 rhinos were poached respectively. The actual predicted values from both the Negative Binomial Models 1 and 2 are presented in Table A1 and Table A2 respectively in the appendix.

Table 4 Estimates from Poisson and Negative Binomial regressions.

Explanatory Variables	Mean (Std. Dev.)	Poisson Model 1	Poisson Model 2	Negative Binomial Model 1	Negative Binomial Model 2	Expected Sign
		Coefficient (Std. Error)	Coefficient (Std. Error)	Coefficient (Std. Error)	Coefficient (Std. Error)	
Constant		-3.5623	-3.0438	- 1.4785	- 1.3248	
		(3.421)	(3.1548)	(2.7215)	(1.3845)	
POPN[-1]	386.7122	0.02659***	0.02488**	0.02239**	0.02191***	+
	(96.7758)	(0.009056)	(0.01024)	(0.01091)	(0.008086)	
APU	1.8387	- 0.1937***	- 0.1920***	- 0.2093***	- 0.2084***	-
	(3.1101)	(0.03537)	(0.03967)	(0.0577)	(0.05575)	
REAL_PEN	934.2333	0.0001615	-	0.00004282	-	-
	(397.1678)	(0.0008615)		(0.000653)		
GDPC_NEP	166.8709	- 0.03664***	- 0.03591**	- 0.04316***	- 0.04303***	-
	(43.424)	(0.01254)	(0.01423)	(0.01627)	(0.01616)	
GDPC_HK[-1]	12268.5484	0.000006861	0.00002029	0.00006965	0.00007361	+
	(8871.0062)	(0.0001094)	(0.00006348)	(0.0000869)	(0.0000625)	
MAOIST	0.2258	1.6229**	1.6232**	1.7585***	1.7588***	+
	(0.425)	(0.6832)	(0.6664)	(0.5311)	(0.5312)	
α		-	-	0.2 (FIXED)	0.2 (FIXED)	
R^2_P		0.768	0.767	-	-	
Log L		- 72.5164	- 72.5781	- 66.1258	- 66.1279	
Overdispersion Test:		g = u(i): 1.902	g = u(i): 1.886			

* Significant at 10%;
** Significant at 5%;
*** Significant at 1%.

6. Discussion

Although the reduced-form poaching function is estimated only as an ad hoc model, it provides an important insight into the factors that are hypothesized to effect levels of poaching in Nepal. Of the main factors considered, only the REAL_PEN was insignificant, as well as of the wrong sign. It is worth noting at this point that the level of penalty over the years has been fixed at two (nominal) levels. Thus, the penalty in real terms over the years has been decreasing significantly. Moreover, as discussed in the conceptual model section (section 3.1), the level of penalties is generally thought to be a deterrent to poachers in terms of entering into poaching activities, but does not necessarily affect the level of poaching per se. In fact, a number of scholars argue that it might actually increase the level of poaching (Clarke, Reed and Shrestha, 1993). Indeed, after the imposition of longer jail terms and higher penalties (post-1993), the level of poaching dropped for a few years but picked up again in 1996. If we are to follow the argument presented in Clark et al. (1993), it does not seem unreasonable to get a positive coefficient in the REAL_PEN. This is because a higher penalty induces poachers that have already entered poaching to poach more in order to offset the high fines they are likely to face if they get caught. However, as the coefficient in REAL_PEN in our estimation stays highly insignificant, we can argue that the level of fines has not been very effective in reducing (or exacerbating) poaching in the RCNP.

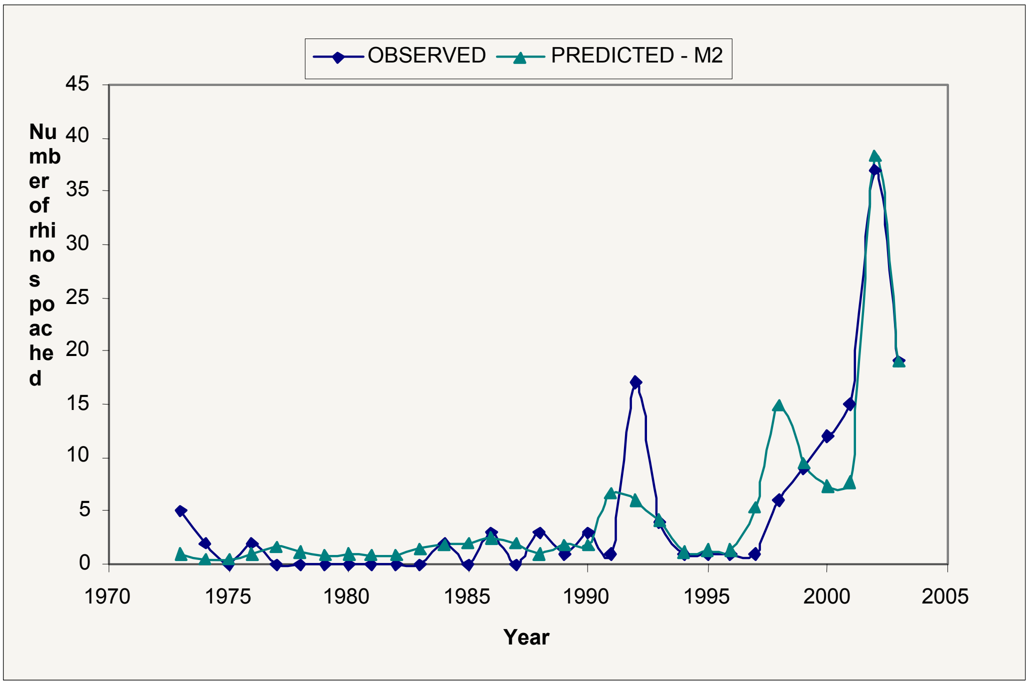

Figure 3 Observed poaching figures and predicted values from the estimation of reduced form poaching function.

The other factor that remained insignificant over all the estimation (although improved significantly in the final model compared to the initial one) was GDPC_HK[-1]. This variable was included in the estimation as a proxy for price of rhino horn on international markets. Since the data on price of rhino horn over the period required for this estimation is almost non-existent, the only way to capture the influence of price on the level of poaching is by using alternative variables like GDPC_HK[-1] as proxy variables. The selection of this variable followed from the fact that Hong Kong is the first international port for the rhino horn trade, as well as a significant consumer itself. The demand for rhino horn (an expensive commodity), depends on the level of income in this region, thereby determining the price. The sign of the coefficient of this variable stayed positive over all the estimations, which shows the consistency of its effect on the dependent variable. However, there could be a better proxy for the price of rhino horn than GDPC_HK[-1]; this could be an area of further exploration, helping to provide better estimates of the reduced form poaching function.

The coefficients on the other four variables – namely POPN[-1], APU, GDPC_NEP, and MAOIST – in the estimation of the reduced form poaching function stayed highly significant over all the estimations. The stock level (POPN[-1]) at the beginning of the year provides the exploitable population for the poachers. As the rhino population in the RCNP has been increasing ever since the establishment of the park, the poachers have higher numbers to poach from every year. However, the objective of the park authority is to have even higher levels of rhinoceros in the park. Thus, we should focus on other factors that increase or decrease the level of poaching within the park. One of the most important factors that influence poaching, both by local poachers and the organised gangs, is the level of anti-poaching effort. The number of anti-poaching units active during the year was used to capture the level of anti-poaching efforts in our estimation of the reduced form model. The APUs have a consistently negative and highly significant effect on the level of poaching in the RCNP; this indicates their importance in rhino conservation. Unfortunately, the APU structure in the RCNP was changed in 2001, and this was followed by a huge increase in poaching in the years 2002 and 2003. Adhikari (2002) also highlights the importance of the APU structure in place until 2001 in controlling the level of poaching in and around the RCNP. In line with the argument presented by Adkikari (2002), this analysis provides strong evidence in favour of continued presence of APUs within and around the RCNP.

The availability of alternative opportunities was captured by GDPC_NEP (per capita GDP for Nepal) in our model, as the local and regional economic indicators required for the estimation were unavailable. This factor also has a consistent negative and highly significant effect on the level of poaching in the RCNP, indicating the importance of alternative economic opportunities in reducing the level of poaching. This is especially important in deterring local poachers in the Chitwan Valley from being involved in poaching, as they are found to come from very poor and landless groups (Gurung and Guragain, 2000). Furthermore, results from this analysis are consistent with the findings of Milner-Gulland and Leader-Williams (1992, 1993) whose studies focused on an African context. They report a reduced level of poaching by local poachers where i) community development activities were initiated, and ii) a greater number of jobs were provided for locals in the tourism sector. In the Nepalese context, Martin (1998) has suggested that the low levels of poaching between the years 1994 and 1997 could be due to the community development projects initiated around the RCNP during that period, as well as local employment/income opportunities in tourism sector (such as in Baghmara Community Forest in the RCNP buffer zone). Thus, consistent with earlier findings, this analysis argues for the creation of alternative economic opportunities locally, so as to deter poachers from poaching.

The ongoing Maoist insurgency in Nepal has been considered a major factor affecting poaching in the RCNP in recent years (Yonzon, 2002). This has especially affected the level of anti-poaching enforcement that involved the RNA being stationed inside the park. The results from this analysis provide strong evidence that this factor has indeed affected the level of poaching in recent years. The estimation from the final model (Negative Binomial Model 2) suggests that the level of poaching increased by nearly 6 rhinoceros a year during the years of the Maoist uprising, compared to the years before the uprising. This is a significant figure, given that the rhinoceros population in the RCNP is about 500 at present. This reflects the importance of political stability in biodiversity conservation, especially in the conservation of species like the one-horned rhinoceros.

This analysis of the historic levels of poaching of the one-horned Indian rhinoceros in Nepal, although crude in its form, has provided valuable insights into the factors that have affected the level of poaching in the RCNP over the years. Although factors like the international price of rhino horn cannot be affected by policies at the national level, there are a number of factors that can be influenced by national policy initiatives in order to help reduce the level of poaching in the RCNP in years to come. The most important of these, given the current situation, seem to be the APU structure, and the creation of local alternative economic opportunities. However, the resolution of the ongoing Maoist uprising would greatly help to conserve this valuable species, given the impact it has had since 1996.

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Appendix

Table A.1 Observed and predicted values for the Negative Binomial Model 1.

Observed Y	Predicted Y	Residual	x(i)b	Pr[Y*=y]
5	0.94528	4.0547	-0.0563	0.0054
2	0.56923	1.4308	-0.5635	0.0914
0	0.48804	-0.488	-0.7174	0.6277
2	0.99855	1.0014	-0.0014	0.1672
0	1.6132	-1.6132	0.4782	0.2471
0	1.1448	-1.1448	0.1352	0.3567
0	0.91932	-0.9193	-0.0841	0.43
0	1.064	-1.064	0.062	0.3811
0	0.7869	-0.7869	-0.2397	0.4815
0	0.86157	-0.8616	-0.149	0.4516
0	1.4599	-1.4599	0.3784	0.2778
2	1.7723	0.2277	0.5723	0.2254
0	1.9766	-1.9766	0.6814	0.1891
3	2.4463	0.5537	0.8946	0.1694
0	2.0501	-2.0501	0.7179	0.1794
3	1.0428	1.9572	0.0419	0.0698
1	1.9068	-0.9068	0.6454	0.2744
3	1.816	1.184	0.5966	0.1406
1	6.6175	-5.6175	1.8897	0.0421
17	6.0122	10.9878	1.7938	0.0039
4	4.3638	-0.3638	1.4733	0.1433
1	1.1279	-0.1279	0.1203	0.3328
1	1.2807	-0.2807	0.2474	0.326
1	1.3625	-0.3625	0.3093	0.3209
1	5.3693	-4.3693	1.6807	0.0675
6	14.72	-8.7201	2.6892	0.0381
9	9.4952	-0.4952	2.2508	0.0775
12	7.4242	4.5758	2.0047	0.0398
15	7.7374	7.2626	2.0461	0.0204
37	38.509	-1.5092	3.6509	0.0222
19	19.146	-0.1464	2.9521	0.041

Table A.2 Observed and predicted values for the Negative Binomial Model 2.

Observed Y	Predicted Y	Residual	x(i)b	Pr[Y*=y]
5	0.9419	4.0581	-0.0599	0.0053
2	0.5723	1.4277	-0.558	0.092
0	0.4915	-0.4915	-0.7103	0.6257
2	0.9971	1.0029	-0.0029	0.167
0	1.6110	-1.6110	0.4768	0.2475
0	1.1451	-1.1451	0.1355	0.3566
0	0.9181	-0.9181	-0.0854	0.4305
0	1.0663	-1.0663	0.0642	0.3804
0	0.7922	-0.7922	-0.2329	0.4793
0	0.8668	-0.8668	-0.143	0.4496
0	1.4641	-1.4641	0.3812	0.2769
2	1.7631	0.2369	0.5671	0.2252
0	1.9626	-1.9626	0.6743	0.191
3	2.4298	0.5702	0.8878	0.169
0	2.0353	-2.0353	0.7106	0.1813
3	1.0472	1.9528	0.0461	0.0702
1	1.9182	-0.9182	0.6514	0.2734
3	1.8329	1.1671	0.6059	0.1417
1	6.6587	-5.6587	1.8959	0.0414
17	6.0848	10.9152	1.8058	0.0042
4	4.2307	-0.2307	1.4424	0.144
1	1.1162	-0.1162	0.11	0.3332
1	1.2796	-0.2796	0.2466	0.3261
1	1.3653	-0.3653	0.3114	0.3207
1	5.4105	-4.4105	1.6883	0.0664
6	14.9130	-8.9125	2.7022	0.037
9	9.5298	-0.5298	2.2544	0.0775
12	7.3979	4.6021	2.0012	0.0396
15	7.7182	7.2818	2.0436	0.0203
37	38.3210	-1.3209	3.646	0.0222
19	19.1340	-0.1340	2.9515	0.041