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**ANALYZING THE PATHWAY TO IMPROVE  
TIGER CONSERVATION IN INDIA**

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Tiger Conservation in India*

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# Analyzing the Pathway to Improve Tiger Conservation in India

Zareena Begum. I and Amanat K. Gill

## Abstract

*Despite substantial conservation investments by governments and international agencies, the existence of tigers in the wild is still threatened. The main threats to the survival of wild tigers are poaching, prey depletion, and habitat degradation and fragmentation. All international trade in tiger parts has been prohibited since 1975, with China introducing a domestic ban in 1993. The domestic trade ban in China was followed by the establishment of captive tiger breeding farms in East Asia. China has considered partially lifting the trade ban to permit sales from tiger farms. This has been a matter of much debate with the proponents to the trade ban opposing it on the grounds that it result in an increase in the illegal killing of tigers and would also result in an increase in demand for tiger products, while the proponents to tiger farming favouring a supply side approach to conservation with products from tiger farms meeting all the demand. This research paper argues that it is possible to protect wild tigers by permitting the sale of products from tiger farms. India has mainly targeted tiger conservation with the establishment of tiger reserves all over the country, but this has resulted in the displacement of local communities from land that was traditionally belonged to them. Community based conservation seeks to conserve wildlife by giving local people a stake in its conservation and thus, providing an incentive to conserve it. This paper using a bio-economic model argues that giving local communities a stake in conservation of tigers like a share of tourism revenues aids conservation, as it would result in an increase in anti-poaching effort undertaken by the local communities, but this is contingent upon the additional revenue being higher than the cost of intrusion.*

**Keywords:** *Community, Domestication, Parameterization, Poaching, Wildlife Management*

**JEL Codes:** *C02, C69, Q26, Q29*

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## **INTRODUCTION**

From more than 100,000 in early 1900s, the population of tigers has dwindled to less than 3,200 today. The Bali tiger became extinct during the 1930s, followed by the Caspian tiger in 1970s and the Javan tiger a decade later. Six species of tiger, namely Bengal, Indochinese, Amur, South China, Malaysian and Sumatran, survive, scattered throughout eastern Russia, Indochina, the Indian subcontinent and Southeast Asia, and have been classified as endangered by IUCN. Tigers have undergone a serious range collapse and today occupy only 7 per cent of their historic range.

Tiger is an umbrella species for the conservation of the biota of a majority of the eco-regions in Asia. Its role as a top predator is vital in regulating and perpetuating ecological processes and systems. Monitoring tiger population is equivalent to monitoring the health of the ecosystems, which the tigers inhabit. India is home to over 50 per cent of the world's wild tigers in spite of having a growing human population of over a billion. It is also one of the world's fastest growing economies. It is with full recognition of these challenges that India is committed to conserving its tigers and their habitats. India plays a vital role in accomplishing the objectives of the Global Tiger Recovery Plan that was ratified at the meeting of world leaders held at St. Petersburg in 2010.

The plight of the Indian tigers came to light, when a census conducted in 1972 revealed the existence of only 1827 tigers in the wild. This resulted in the initiation of 'Project Tiger' in 1973, which sought to conserve tigers with the establishment of tiger reserves. Today there exist a total of 39 tiger reserves with a population of 1706 tigers. Currently tigers occur largely in the forest areas of 17 states in India. Nagaland, Meghalaya, Tripura and Haryana have reports of occasional tiger occurrence. The distribution of tigers and their density in these forests vary on account of several ecological and anthropogenic factors

like forest cover, terrain, natural prey availability, presence of undisturbed habitat and the quality of managerial efforts taken towards protection.

The main threats faced by wild tigers today is poaching to feed the illegal trade in skins and bone, depletion of natural prey and habitat destruction and fragmentation. Despite the prohibition of international trade in tiger parts and its products, with the listing of the tiger in Appendix A of UN Convention on International Trade in Endangered Species (CITES) in 1975, the lucrative trade in tiger parts still continues. The number of poached tigers between 1994 and 2011 is 936, but this does not even begin to indicate the gravity of the problem since most of the poaching goes undetected. With the demand for tiger products miniscule in India, most of the poaching is carried out to meet the demand overseas especially in China, where tiger bone is used in traditional oriental medicine, wine etc and tiger skin is used in home décor, taxidermy and bribery. Much of the tiger poaching is done by tribal's who know their forests well. They are usually paid a meager amount, their hunting talents and knowledge is exploited by greedy traders.

Despite a country wide increase of 20 per cent in tiger population, from 1411 in 2006 to 1706 in 2010, there has been a decline of 12.6 per cent in tiger occupancy from connecting habitats, from 93,697km<sup>2</sup> in 2006 to 81,881 km<sup>2</sup> in 2010. The existence of migration corridors between reserves is essential to enhancing the conservation potential by increasing the viability and resilience of the wild tiger population by overcoming the genetic consequences of an inbred tiger population as a result of isolated tiger reserves. Habitat destruction and associated natural prey decline, as well as hunting of prey species, forces tigers into conflict with local communities and the vicious cycle of human-predator conflict.

The protected areas in India are comparable to small islands in a vast sea of ecologically unsustainable land uses of varying degrees. To ensure that these natural systems continue to provide ecosystem services and remain repositories of biodiversity for future generations, it is essential to 1) protect them from human impacts, and 2) maintain natural areas of sufficient size so as to allow for ecosystem processes to occur. Tigers need large areas of undisturbed habitats to sustain tigers in the long run. This dilemma can be addressed by managing these “small” tiger populations as meta-populations. By permitting tigers to migrate between reserves, the long term persistence of individual populations is enhanced. The “tiger bearing forests” need to be fostered with protection as well as restorative inputs to ensure their source and corridor value for demographic and genetic viability of tiger populations. Tigers are a conservation dependent species requiring connected forests with good prey and a fair interspersion of undisturbed breeding areas.

## **LITERATURE REVIEW**

### **Domestication of Tigers and Illegal Trade**

With more than 100,000 tigers at the beginning of the twentieth century, the population of tigers has fallen to fewer than 3,200 today. Across their range, tigers are seriously threatened by poaching to feed the illegal trade in skins and bones, habitat destruction and decline in natural prey populations. Tigers (*Panthera tigris*) have been listed on Appendix A of the UN Convention on International Trade in Endangered Species (CITES) since 1975, with the exception of the Siberian sub-species, which was added in 1987. All international trade in tiger parts and products is strictly prohibited but the demand for tiger bone for traditional medicines and the burgeoning market for skins continues, and a recent analysis by TRAFFIC reveals that on an average a minimum of 104 tigers have entered trade every year between 2000 and 2010. In India, home to nearly half of the world’s remaining wild tiger population; the current population is officially estimated to be 1706 (MoEF) as compared to

40,000 in the beginning of the twentieth century. At this rate, wild tigers are faced with a future of being confined to a small number of isolated reserves and as captured animals in zoos and private holdings (Environmental Investigation Agency, 2010).

The illegal trade in poached skins between India, Nepal and China is the most significant immediate threat to the continued existence of the tiger in the wild. While the gravity of the situation has been recognized and plenty of information is already available, the lucrative illegal trade continues. The fundamental reason being, that the Governments in question have failed to implement an adequate enforcement response at the domestic and regional levels. Wild life crime remains a low priority in terms of political commitments and investment, and is rarely subjected to sustained and specialized enforcement effort (Environmental Investigation Agency and Wildlife Protection Society of India, 2006).

In the early 1990s, China emerged as a major importer and consumer of tiger bone and an exporter of tiger bone products, surpassing Thailand and Indonesia as the primary supplier to markets in South Korea and Japan. China's growing domination of the marketplace coincided with reports of increased tiger poaching in India, starting in the late 1980s (Environmental Investigation Agency, 1996).

In 1993, following intense international pressure, China introduced a domestic trade ban on the sale of tiger parts and derivatives. This was aided by donors and NGOs launching global campaigns to engage the practitioners of Traditional Asian Medicines, working together to promote alternatives. Despite the official move away from patented and packaged tiger bone medicines, tigers continued to be poached in India.

In December 1999, the illegal tiger trade again exploded onto the international agenda with the seizure in India of a large consignment of skins: three tiger, 50 leopard and five otter in one truck in Ghaziabad, Uttar Pradesh. Weeks later, in January 2000, leads from this seizure resulted in a massive haul in the small town of Khaga, also in Uttar Pradesh, comprising four tiger, 70 leopard, 221 otter skins, 175kg of tiger bone, 132 tiger claws and approximately 18,000 leopard claws. Not only was the skin trade escalating, there was clearly still demand for bones and other body parts. Information from both seizures suggested the old trade connections with Tibet and China were still flourishing (Environmental Investigation Agency and WPSI, 2006). By the end of 2004, news was beginning to emerge that all the tigers in India's Sariska Tiger Reserve had been exterminated, while the loss of tigers in Panna Tiger Reserve was also reported (Environmental Investigation Agency and WPSI, 2006).

Although appeals by religious leaders and targeted outreach campaigns have reduced demand from the Tibetan community, without law enforcement operations targeting the criminals profiting from the trade, trafficking in Asian big cat skins and parts into China has continued via the same routes.

Importantly, there has been a clear shift in favour of meeting the demand for skins to be used as home décor, taxidermy and for bribery. Many skins are now sold with the head and paws intact, or backed onto cloth for display (Environmental Investigation Agency, 2009). According to traders selling skins in 2007–09, the primary buyers have also changed and are principally the mainland Chinese business elite, officials and the military. Investigations in 2009 revealed that tiger and leopard bones continue to flow into a network of dealers selling to mainland Chinese for medicinal purposes, with customers apparently purchasing the raw, authentic item over patented packaged products. Tiger bone is also increasingly used in tiger bone wine, marketed as a gift or "tonic", with

large volumes advertised openly at wildlife parks and tiger breeding centres.

Environmental Investigation Agency has identified the obstacles to enforcement as:

- Lack of understanding and capacity, and unclear policies
- Lack of resources
- Lack of cooperation and trust
- Lack of motivation compounded by corruption and institutional weaknesses.

Some key recommendations by Environmental Investigation Agency are as follows:

- Secure greater involvement of police and custom officers in tiger and other Asian big cat conservation
- Reduce demand for tigers and other Asian big cat parts
- Expand the use of intelligence led enforcement in combating tiger trade
- Improve international cooperation to disrupt transnational criminal networks
- Reform of judicial processes
- Increase resources to combat wildlife crime
- Improve the motivation of enforcement personnel
- Tackle corruption in wildlife crime.

The most common recommendation for preventing the extinction of wild tigers is to increase enforcement of the trade bans, while opposing tiger farming, which sprung up following China's domestic trade ban on tiger products and its derivatives, on the grounds that farmed output removes the stigma of using tiger-based products and facilitates laundering of illegal tiger parts. On the other hand, proponents of tiger farming and permitting the sale of captive breeding farms favour a supply side approach to conservation, arguing that a captive breeding

industry could meet the demand for tiger products, thereby eliminating or reducing the illegal killing of wild tigers and aiding conservation.

Damian and Bulte (2005, 2007) assume imperfect competition to demonstrate theoretically that multiple equilibria are possible in a game between organized criminal poaching gangs and domestic wildlife farms. In their model, it is not possible to determine unambiguously whether products from captive-bred wildlife will increase or decrease harvests of wild animals. If poachers and farmers compete on the basis of quantity (Cournot competition), the solution to the game leads to higher populations of wild tigers; but if competition is on the basis of price (Bertrand competition), wild stocks are reduced. However, as Singh and Vives (1984) demonstrate, the poacher and farmer are unlikely to compete on the basis of price since they both can do better if they compete on the basis of quantity when the goods they market are substitutes i.e. the Cournot outcome dominates the Bertrand outcome, if wild and farmed products are substitutes, and especially if demand is linear (as assumed by Damian and Bulte, 2005, 2007).

The model used by Abbott and Kooten (2011), to evaluate the potential of permitting the sale of domesticated tiger products, indicates that, in the absence of the required institutions or effective community based resource management regimes that inhibit illegal takings, the sale of tiger products from tiger farms could reduce poaching sufficiently to enable wild tigers to reproduce faster than they are killed. In the absence of other measures (additional food or habitat), a combination of increased enforcement and legal sales offers the best chance of wild tiger survival. However, the loss of quality habitat makes it difficult to design an effective strategy for saving wild tigers.

Their simulation results assume that anti-poaching enforcement efforts and the demand for poached tigers will be unaffected if tiger farming is legitimized, other than through the 'stigma effect' (which

postulates that the demand for wildlife products falls when trade is banned) that causes the demand to shift outwards if trade is permitted. However, these assumptions can be debated on the following grounds (Kirkpatrick and Emerton, 2010):

- Legalisation of farmed tigers increases the demand for poached tigers because farmers will purchase them to increase their captive stocks.
- Legalisation of farmed tigers increases poaching because it is much cheaper to poach a tiger than to raise one in captivity; thus, producers of tiger products purchase poached animals and sell them as if they were raised in captivity.
- Since, there will be legal as well as illegal supply of tigers, it will be harder to recognise poached tigers and the effectiveness of anti-poaching efforts will be reduced.

These would be warranted if tiger farming was unregulated with many competitive firms. However, if tiger farming is concentrated in a single or a very small number of regulated monopolistic firms, these concerns may not materialize, since, there is an added incentive to defend property rights, which could lead to greater anti-poaching enforcement to protect their profits. To help ensure that poached wild tigers are not laundered into the stock of captive bred tigers, an animal registration system similar to the one used for cattle in Europe and North America can be adopted (Abbott and Kooten, 2011).

### **Community Based Wildlife Management**

The plight of the Indian wild tigers came to light, when a census conducted in 1972 revealed the existence of only 1827 tigers as compared to approximately 40,000 tigers in the early 1900s, which led to the launch of 'Project Tiger' in 1973. The various reasons responsible for the fall in the tiger population were:

- shrinkage of tiger habitat

- excessive disturbance in tiger habitat
- depletion of tiger prey
- poaching of tigers
- poisoning for the protection of cattle

'Project Tiger' targeted conservation of tigers by the creation of tiger reserves. The tiger reserves followed a 'core-buffer' model, wherein tiger reserves are divided into 2 zones – the 'core' area which is devoid of human interference and the 'buffer' area which is subjected to conservation oriented land use. One major drawback of this 'fines and fences' approach to conservation was that it led to the displacement of people from the land that was traditionally theirs. 'Project Tiger' suffers from various other problems as well – delayed and inadequate funds, poaching, grazing, encroachment and inadequately trained and insufficient number of field staff (Khandelwal, 2005).

Most of the national parks, where tigers breed, are small and the land-use changes, resulting in the destruction of migration corridors between reserves, threaten to increase reserve and population isolation. Both site-level protection and landscape-scale interventions, to maintain habitat corridors, is essential, in order to maintain the viability and resilience of wild tiger population by managing tigers as metapopulations. Source sites alone do not have the potential to meet the range-wide goal of doubling the population, effective protection of tigers and prey at the current range-wide reserve system is essential. The tiger's ecological and demographic requirements, and genetic consequences of isolated tiger populations, demand a landscape approach that goes beyond reserve boundaries (Wikramanayake *et. al.*, 2010).

In response to the recognized failure of top-down approaches to development, and ecological limits of fortress conservation, Community Based Conservation, CBC, has become the trademark of the "new conservation" approach, which is now unfolding across Africa. CBC shifts

the focus of conservation from nature as protected exclusively by the state, to nature as managed through inclusive, participatory, community based approaches. Its premise was that giving local people a stake in wildlife would increase their incentive to conserve it. This would therefore make wildlife an important engine of local economic development. Community-based conservation seeks to create a synthesis between conservation and development (Igoe, 2004).

A study, carried out by Tynnerson (2009), of the 'Burunge Wildlife Management Area in Tanzania', revealed that while gains for the local communities were not clear, gains for wildlife were more evident. Both species numbers and individuals increased, but at the same time there was also an increase in conflicts between locals and wildlife. Officials in Babati District claim that the project has been a success. Positive effects for the people have been that the villages have more money for development, people have been employed in the tourism and handicraft industries, people are proud of the project and benefit from tourism. Positive effects for wildlife from the project have been an increase in wildlife, and occurrence of wildlife in new places. The community has more knowledge about wildlife, and there is less poaching. Some negative aspects in the area include some illegal grazing and poaching, mostly by Maasai (semi-nomadic tribals). There have been conflicts between wildlife and farmers, with elephants, zebras and bushpigs raiding fields, and lions killing livestock. At the moment there is no compensation for the farmers who get their fields destroyed or lose their livestock.

Bulte and Horan (2003) developed a model of open-access wildlife exploitation, habitat conservation, and agriculture, in which farmers may either hunt for wildlife or grow crops. They showed that increasing wildlife conservation may well be Pareto-superior to equilibria in which agriculture dominates.

A bio-economic model, formulated by Fischer, Muchapondwa and Sterner (2005) to analyse community incentives for wildlife management before and after CAMPFIRE, a programme which was created to institute sustainable management practices for wildlife, land, and other natural resources by rural communities in Zimbabwe in 1989, showed that resource sharing with local communities can have ambiguous effects on both conservation incentives and welfare. Two agents influence the wildlife stock: a parks agency, which determines hunting quotas, and a local community, which chooses to either collaborate with or discourage poachers from outside the area. Wildlife generates economic benefits both from the sale of hunting licenses and from non-consumptive tourism; however, it also intrudes on the agricultural rents of the local community. Since a larger wildlife stock reduces agricultural returns, the community will engage in anti-poaching efforts only if they reap benefits from wildlife activities. The conservation incentives depend critically on three factors: the type of resource activity that generates the shared profits, the extent to which these shared profits outweigh agricultural losses from additional wildlife, and the way that the parks agency responds to profit sharing and whether the community internalizes this response.

Evidence from some areas in Zimbabwe indicates that poaching was rampant prior to CAMPFIRE. Post CAMPFIRE, poaching has been drastically reduced in some areas as the neighbouring communities started reaping economic benefits from legal wildlife utilization and consequently began to make public arrests of commercial poachers (Child *et. al.*, 1997). However, in other areas, poaching subsided only temporarily with CAMPFIRE and then bounced back after a few years.

### **Objective**

Based upon the literature reviewed, the following objectives are set for the present research work:

- To theoretically analyze the impact of permitting sales from captive-tiger breeding farms, in China, on the population of wild tigers in India. More specifically, parameterisation of the tiger survival functions in the context of India.
- To show how the application of Community Based Wildlife Management, in the 'buffer' zone of a tiger reserve and in migration corridors between tiger reserves in India, would aid tiger conservation and would also result in the existence of a viable and resilient wild tiger population.

## **DOMESTICATION OF TIGERS**

The illegal trade in poached skins between India, Nepal and China is the most significant immediate threat to the survival of tigers in the wild. Even though international trade in tigers has been prohibited since 1975 with the listing of the species under Appendix A of CITES, with the exception of the Siberian sub-species which was added in 1987, and China has imposed a domestic ban on trade in tiger parts and its derivatives in 1993, the lucrative trade in tiger parts still continues.

The domestic ban on trade in tiger parts in China coincided with the onset of domestication of tigers with the establishment of tiger breeding facilities. In recent years, captive breeding of tigers has accelerated to the point where the captive tiger population exceeds 4000. Tiger farming can be looked upon as a supply-side approach to conservation of wild tigers, which seeks to eliminate or reduce the illegal killing of wild tigers and aid their survival by meeting all the demand for tiger products.

It is a common knowledge that organized criminal networks are attracted to wildlife crime because it offers high profits with little risk of detection and prosecution. The presence of captive-bred tigers would result in an increase in the total supply of tiger products, thus, reducing

their price and making poaching a less profitable enterprise. However, the introduction of farmed tigers in the market would reduce the 'stigma effect' associated with the prohibition of tiger trade.

It is argued that the costs of raising tigers in captivity are considerable due to which the farmers are unable to undercut suppliers of illegal wildlife products. However, the costs of processing and marketing poached animals, such as the payment of bribes, opportunity cost of conviction etc, are underestimated. The existence of tiger farms despite a trade ban indicate that the associated costs of captive tiger breeding may not be burdensome and there may be benefits specific to tiger farming, like paid public viewing.

Despite the outlawing of killing tigers in India in 1972 and the prohibition of international trade in tiger parts in 1975 under CITES, poaching of tigers continues at an alarming rate in India. With the demand for tiger products miniscule in India, poaching is carried out mainly to meet the demand outside the Indian borders, particularly China. With the supply from captive-breeding farms meeting the demand for tiger products, poaching in India is expected to fall with the legalizing of sale of tiger products from captive-tiger farms.

Using the mathematical bio-economic model developed by Abbott and Kooten to evaluate whether domestication of tigers would aid conservation, we try to evaluate the potential of this domestication of tigers in East Asia to support conservation in India.

### **Model**

The population of wild tigers ( $x$ ) is characterized by the single species growth function with 'Allee effect':

$$G(x(t)) = gx(t) \left[ \frac{x(t)}{m} - 1 \right] \left[ 1 - \frac{x(t)}{K} \right] \quad (1)$$

where,  $m$  is the minimum viable population,  $K$  is the population carrying capacity and  $g$  is the intrinsic growth rate.

The harvest function is given by a square-root variant of the standard constant returns to scale Schaefer production function:

$$H(x, L_p) = \theta x^{1/2} L_p^{1/2} \quad (2)$$

where,  $\theta$  is the catchability coefficient and  $L_p$  is the fraction of time spent on poaching.

The expected payoff to the poacher from both legitimate activities and poaching is

$$E[u(x, L_p)] = (1 - \pi)[w(1 - L_p) + p \theta x^{1/2} L_p^{1/2}] + \pi[w(1 - L_p) - \epsilon] \quad (3)$$

where,  $\pi$  is the probability of apprehension,  $p$  is the price of tiger parts,  $w$  is the wage rate in other employment and  $\epsilon$  is the penalty faced on apprehension.

The first term of equation (3) is the payoff to a poacher who avoids detection weighted by the probability of avoiding detection, while the second part is the payoff to a poacher who gets caught weighted by the probability of apprehension.

A rational expected utility maximizing poacher will choose  $L_p$ , such that the marginal benefit of time spent poaching is equal to its opportunity cost given by the wage rate.

$$\frac{1}{2} \theta x^{1/2} L_p^{1/2} (1 - \pi) p = w \quad (4)$$

Solving for  $L_p$  and substituting in equation (2) gives us

$$L_p = \left[ \frac{\theta(1-\pi)p}{w} \right]^2 x \quad (5)$$

$$H(x) = \frac{\theta^2(1-\pi)xp}{2w} \quad (6)$$

$$\theta = \sqrt{\frac{2Hw}{(1-\pi)xp}} \quad (7)$$

The tiger survivability function is given by

$$\frac{d\dot{x}}{dt} = G(x) - H(x) = gx(t) \left[ \frac{x(t)}{m} - 1 \right] \left[ 1 - \frac{x(t)}{K} \right] - \frac{\theta^2(1-\pi)xp}{2w} \quad (8)$$

The illegal supply of tigers is given by  $(1 - \pi)H$ ,

$$S(p) = \frac{\theta^2(1-\pi)^2xp}{2w} \quad (9)$$

Assuming a linear derived demand function for wild tigers,  $D(p) = \alpha - \beta p$ , with  $\alpha, \beta > 0$ . Equating demand and supply and solving for price and substituting in equation (8) gives us,

$$\theta = gx(t) \left[ \frac{x(t)}{m} - 1 \right] \left[ 1 - \frac{x(t)}{K} \right] - \frac{\alpha\theta^2(1-\pi)x}{(1-\pi)^2\theta^2x + 2w\beta} \quad (10)$$

With the inclusion of sale of captive-bred tigers, the supply of tigers changes to

$$S(p) = \frac{\theta^2(1-\pi)^2xp}{2w} + \Omega \quad (11)$$

where,  $\Omega$  is the amount supplied by tiger farms.

Solving for price by equating demand with supply and substituting in equation (8) gives us,

$$\theta = gx(t) \left[ \frac{x(t)}{m} - 1 \right] \left[ 1 - \frac{x(t)}{K} \right] - \frac{(\alpha - \Omega)\theta^2(1-\pi)x}{\theta^2(1-\pi)^2x + 2w\beta} \quad (12)$$

Partially differentiating equation (12) with respect to  $\Omega$  gives the impact of sale of captive bred tigers on the dynamics of tiger population, which is seen to be positive.

$$\frac{d\dot{x}}{d\Omega} = \frac{\theta^2(1-\pi)x}{\theta^2(1-\pi)^2x+2w\beta} > 0 \quad (13)$$

The direct effect of permitting the sale of farmed tigers, on the survival of wild tigers, is seen to be positive i.e. permitting sale of farmed tigers would lead to an increase in the rate of population growth of wild tigers. But the overall impact of sale of farmed tigers on the population of wild tigers is uncertain, and depends on whether supply of farmed tigers outweighs the stigma effect, which is given by the change in  $\alpha$  due to the presence or absence of trade ban on tiger products. This can be shown by partially differentiating equation (12) with respect to  $(\alpha - \Omega)$ .

$$\frac{\partial \dot{x}}{\partial (\alpha - \Omega)} > 0 \text{ if } \Omega > \alpha \quad (14)$$

$$\frac{\partial \dot{x}}{\partial (\alpha - \Omega)} < 0 \text{ if } \alpha > \Omega \quad (15)$$

## PARAMETERIZATION OF TIGER SURVIVAL IN INDIA

Parameter	Description	Value	Estimation
$K$	Carrying capacity	4094	Habitats can support an average of 5 adult tigers per 100km <sup>2</sup> , in areas with higher prey densities and/or smaller tiger sub-species (Dinerstein <i>et. al.</i> , 2006). Tiger occupancy in India is 81,881 km <sup>2</sup> (WII, 2010); this habitat can support 4094 tigers.
$m$	Minimum viable population	780	With 39 tiger reserves in India (MoEF) and a minimum population of approximately 20 tigers in each to ensure survival (Dinerstein <i>et. al.</i> , 2006) implies a minimum viable population of 780 tigers for India.
$p$	Price of poached tiger	\$20 (local poachers); \$20,000 (organized gangs engaged in wildlife crime); \$56,000 (traders)	Local poachers' and organized gangs engaged in wildlife crime →WPSI, 2001. Traders in China →EIA, 2009 (see Appendix A).
$\pi$	Probability of apprehension	0.1	To reach an estimate of the magnitude of the poaching of tigers in India, the customs authorities multiply known offences by ten to estimate the size of an illegal trade (WPSI, 2012). This implies a 0.1 probability of apprehension.
$w$	Wage rate in other employment	INR.73.57 ( $\approx$ US\$1.5)	Based on the report, 'Wage Rates in Rural India, 2008-09', by the Labour Bureau, Ministry of Labour and Employment, Government of India, the average wage over the agricultural and non-agricultural occupations, and men, women and children is INR.73.57 (Appendix B).

Parameter	Description	Value	Estimation
$\epsilon$	penalty	INR. 10,000 ( $\approx$ US\$200)	Wildlife (Protection) Act, 1972 [Amendment Act, 2002], Ministry of Environment and Forests (Appendix C).
$g$	Intrinsic growth rate	0.087	Dinerstein <i>et. al.</i> (2006) estimated that only 20 per cent of newborns will have an opportunity to breed, annual reproduction averages 0.61 per young female and there are 2.5 females per male. This implies an intrinsic growth rate of 0.087 ( $0.2 \times 0.61 \times 25/3.5$ )
$\theta$	Catchability parameter	0.3	Calculate using eq <sup>n</sup> (7). $H = 936$ (WPSI) (see Appendix D), $x = 1706$ (MoEF), $p = \text{US\$}20$ (since poaching is undertaken by locals who have an intimate knowledge of the forests).
$\alpha$	Demand intercept (measuring the stigma effect)		Using the demand function: $D(p) = \alpha - \beta p$ . $D(p) = 104$ (TRAFFIC $\rightarrow$ on an average a minimum of 104 tigers have entered trade every year between 2000 and 2010); $p = \text{US\$}56,000$ (value of a tiger to the traders in China).
$\beta$	Price elasticity of demand		Assumed values

## COMMUNITY BASED WILDLIFE MANAGEMENT

With an estimated 40,000 tigers at the beginning of the twentieth century, the number of tigers in India continuously declined in the absence of legal constraints. The gravity of the situation was first realized when the first all-India tiger census revealed the existence of only 1827 tigers in India. In order to combat the declining tiger population, the

Government of India enacted the Wildlife Protection Act of 1972 and launched 'Project Tiger' in 1973.

Project Tiger seeks to conserve tigers by protecting their habitat and minimizing human interference with creation of tiger reserves. Launched with 9 tiger reserves, Project Tiger currently has 39 tiger reserves under its umbrella, with 4 more in the process of being added to this count. It followed a 'core-buffer' model, wherein the 'core' area is devoid of any human presence or activity and the 'buffer' area is subjected to conservation oriented land use only.

Even though this traditional way of conserving tigers, through the creation of national parks and reserves known as the 'fences and fines', may have aided tiger conservation to a certain extent, it has also displaced communities from land that was traditionally theirs. While the wildlife, on the other hand, could roam freely in the surrounding areas, destroying crops and threatening livestock and people. Thus, the creation of national parks and reserves created a conflict between wildlife conservation and agricultural development.

Community Based Wildlife Management (CBWM) seeks to resolve this problem by making tigers an important engine of economic development. It is based on the premise that giving local people a stake in tiger conservation would increase their incentives to conserve tigers. The core elements of CBWM are development, conservation and sustainable land use.

Migration corridors connecting reserves are essential to the conservation of tigers. Genetically, in most of the tiger reserves, the tiger population is too small to maintain long term viability and persistence. Migration corridors maintain connectivity which allow greater gene flow between sub populations and mitigate further inbreeding depression in these populations without the cost of translocations. Maintaining

migration corridors between reserves, is also necessary to achieve other important conservation targets, such as, to increase the resilience of tiger populations and maintain the natural ecology and behaviour of tigers for long term persistence.

A landscape approach to conservation that goes beyond reserve boundaries is vital to the long term conservation of tigers (Wikramanayake *et. al.*, 2010). A possible step towards such conservation can be the protection of the migration corridors between reserves and the application of CBWM in these corridors as well as the 'buffer' zone in tiger reserves, as it would not only meet the tiger's ecological and demographic requirements, and avoid the genetic consequences of isolated tiger populations but also create a synthesis between conservation and development.

Communities when viewed as small and homogenous units are seen as better positioned to realize conservation goals, and as necessary allies in the expansion of conservation beyond national park boundaries and into human-inhabited rural landscapes (Igoe, 2004). Providing the right incentives, like sharing revenue from wildlife services, can induce communities to engage in conservation activities. In the absence of such incentives, the presence of tigers may be regarded as a menace by the local communities and they may be less inclined to alert the authorities to poachers and more likely aid the poachers or poison the carcasses of livestock killed by tigers. The anti-poaching effort exerted by the communities makes poaching more difficult and expensive since poachers cannot count on local support, thus aiding conservation through reduced poaching.

Using a model, devised by Fischer, Muchapondwa and Sterner (2005) to evaluate the incentives for wildlife management before and after CAMPFIRE, we can see that sharing revenue from non-consumptive wildlife service's like, benign tourism, between park agency and local

communities provides an incentive to the local communities to engage in anti-poaching activities provided the share of revenue received by the communities is greater than the cost of anti-poaching activities, they engage in. The positive impact of an increase in anti-poaching activities on tiger conservation due to the contribution of the local communities is shown using the model, used in the previous chapter, devised by Abbott and Kooten to evaluate the impact of tiger farming on tiger conservation.

## **Model**

The bio-economic model comprises of one agent (a local community), one control variable (anti-poaching effort) and a stock variable (tiger biomass). Economic rents are generated from non-consumptive wildlife services, like tourism, which is distributed between the park agency and the local community, and from agricultural production, which solely benefits the community. It is assumed that the local communities do not benefit directly from poaching proceeds; rather they choose the degree to which they collaborate with or oppose poachers, based on their perception of the value of tigers to them.

The 'core' area of the national reserve is devoid of human interference, while the local community has user rights over the 'buffer' zone and the migrating corridors between reserves. The main agricultural alternatives outside the national park are livestock and crop production. The tigers tend to wander outside the park into the surrounding areas, threatening livestock. The ecological interaction between tigers and agricultural productivity is assumed to be unidirectional and is represented by a revenue function that is declining and convex in the stock of tigers ( $x$ ) i.e.  $R'(x) < 0$  and  $R''(x) > 0$ .

The revenue from tourism is increasing in the stock of tigers i.e.  $T'(x) > 0$ ;  $T''(x) < 0$  and  $T(0) = 0$ . The local communities get a share of the profits from benign tourism ( $\tau$ ). We assume that  $\tau$  is fixed through time and  $0 < \tau < 1$ . The remaining profit goes to the park agency.

The anti-poaching activities ( $A$ ) undertaken by the community involve costs, like value of time lost, wages for private enforcement agents etc. and is represented by a function that is increasing and convex in positive effort i.e.  $C'(A) > 0$  and  $C''(A) > 0$ .

The community's utility function is the sum of revenues earned from agriculture and tourism minus the costs of undertaking anti-poaching efforts i.e.

$$V(x, A) = R(x) + \tau T(x) - C(A) \quad (16)$$

The local community maximizes the present value of its income by choosing  $A$  subject to the dynamics of the tiger population.

The growth in the stock of tigers is given by

$$\theta = G(x) - H(x, A) \quad (17)$$

where,  $G(x)$  is the natural growth function and  $H(x, A)$  is the harvest function, representing the loss due to poaching. The harvest function is increasing in the stock of tigers and decreasing in anti-poaching effort i.e.  $H_x(x, A) > 0$  and  $H_A(x, A) < 0$ . It is important to note that poaching will never be zero no matter how large  $A$  is, since a certain amount of poaching cannot be detected even with the co-operation of the local communities.

The current value Hamiltonian is

$$Y = V(x, A) + \mu[G(x) - H(x, A)] \quad (18)$$

The first order condition with respect to anti-poaching effort is

$$-C'(A) + \mu[-H_A(x, A)] = 0 \quad (19)$$

The dynamics of the shadow value of the tiger stock to the community is defined by

$$\frac{\partial \mu}{\partial t} = [R_x(x) + \tau T_x(x) + \mu(G'(x) + H_x(x, A))] \quad (20)$$

Steady state implies  $\frac{\partial \mu}{\partial t} = 0$  and the shadow value of tiger equals

$$\mu^* = \frac{R_x(x) + \tau T_x(x)}{\delta - G'(x) + H_x(x, A)} \quad (21)$$

From equation (19) we see that anti-poaching effort is strictly increasing in the shadow value of tigers to the community i.e.  $\frac{dA}{d\mu} > 0$ , and from equation (21) we see that the equilibrium shadow value of tigers is unambiguously increasing in  $\tau$  i.e.  $\frac{d\mu}{d\tau} > 0$ . Thus, anti-poaching effort is strictly increasing in  $\tau$  i.e.  $\frac{dA}{d\tau} > 0$ .

The impact of anti-poaching on tiger population can be shown by

$$\frac{d\theta}{d\pi} = \theta^2 \frac{xp}{2w} = \frac{\alpha \theta^2 x}{[\theta^2(1-\pi)^2 x + 2w\beta]} > 0 \quad (22)$$

Hence, sharing tourism revenues increases anti-poaching efforts, which in turn imply an increase in the probability of apprehension ( $\pi$ ), and thus, aid conservation.

## **CONCLUSION**

### **Domestication of Tigers**

The bio-economic model used indicates that permitting sales from captive bred tiger farms can aid the conservation of tigers. It has the potential to curb the illegal trade in tiger parts by meeting the demand for tiger parts. Patients who have been unable to obtain their medicines legally have no choice but to go to illegal channel for tiger bones. If legal channels exist and patients can legally get tiger bone for their medicine, the motivations

to purchase tiger bones from illegal sources can be minimized. Also, an increase in supply can also lower the price of tiger products. Thus, it can result in compressing the huge profits made by smugglers and poachers and poaching of tigers is less attractive. This type of approach has successfully worked in the conservation of certain endangered species, like crocodiles in 1970s and vicuna in 1988.

To date, conservation measures have focused on curbing demand for tiger parts, by combating poaching and securing the tiger's habitat. Unfortunately, the efforts in these areas have not borne fruit, since poaching is still rampant and the tiger habitat is eroding due to the human pressures. Management of the supply side of trade in tigers and their parts remains largely unexplored.

However, permitting sales of captive bred tiger farms alone is not sufficient, it must be complemented by increased enforcement to ensure that the parts being sold are indeed from captive tigers and that poached tigers are not 'laundered' into the stock of captive bred tigers. A possible solution to this could be enforcing an animal registration program similar to the one implemented in Europe and North America for cattle. To increase the effectiveness of legalising sales from tiger farms, we can introduce the incentive to defend property rights by granting exclusive rights to certain farmers to manage tiger farms and sell tiger products. However, the loss of tiger habitat makes the designing of an effective strategy for the survival of tigers in the wild very difficult.

### **Community Based Wildlife Management**

A CBWM programme wherein the local communities share the revenue generated by non-consumptive wildlife services, like tourism, leads to increase in anti-poaching effort undertaken by the communities. Since, the poachers base their decisions regarding the harvest on the amount of effort exerted and the cost of undertaking poaching activities, an increase in anti-poaching activities by the local communities will curtail poaching,

as it is costlier for them to undertake such activities and the effort required is higher as well. But we must keep in mind that the success of such a programme is contingent upon the additional revenues generated from wildlife service's being higher than the cost of intrusion i.e.  $\tau T'(x) > -R'(x)$ , for if it is not so then the local communities have no incentive to carry out anti-poaching activities as it is costlier for them to do so. The success of CBWM in aiding conservation depends upon the design of the revenue sharing system; the revenue earned by the local communities from wildlife services must be higher than the cost of anti-poaching effort exerted and the cost of intrusion.

A way forward from the current 'fences and fines' can be the implementation of CBWM in the buffer zone of a tiger reserve and in the migration corridors between reserves. This will not only solve the field staff shortage faced by the tiger reserves under 'Project Tiger' but will also provide the community an incentive to engage in anti-poaching activities and since tigers will no longer be looked at as pests but as an asset. Since, local people and tribesmen are usually hired by the organized criminal gangs engaged in wildlife crime to carry out poaching, the increase in anti-poaching activities by the local communities and the refusal to engage in poaching by the locals would increase the cost and effort faced by the organized criminals and make poaching less attractive as not only will the costs increase but the risk as well since the probability of apprehension will increase as well. Also, maintaining and protecting the migrating corridors between reserves is essential to the long run survival of the existing wild tiger population, as they increase the viability and resilience of the tigers by overcoming the genetic consequences of an inbred tiger population which would result due to isolated reserves and populations, and it would also reduce the translocation cost.

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## APPENDIX A

### Illegal Selling Price of Tiger Parts

Item	Price Range
Full tiger skin	Approx. US\$11,764 – US\$22,058
Tiger teeth	Approx. US\$661 [1 tiger → 30 teeth]
Tiger bone	Approx. US\$882 – US\$1,176 per kg. [1 tiger → 12kg]

**Source:** Environmental Investigation Agency, 2009.

## APPENDIX B

### WAGE RATES IN RURAL INDIA (2008-2009)

#### All-India Annual Average Daily Wage Rates in Agricultural Occupations during the year 2008-2009 (Occupation-wise)

(in Indian Rupees)

Occupation	Men	Women	Children
Ploughing	102.90	55.43	—
Sowing	90.00	65.00	48.91
Weeding	80.15	68.02	49.46
Transplanting	83.28	71.43	52.51
Harvesting	87.05	71.58	50.49
Winnowing	81.23	65.08	43.40
Threshing	85.06	67.66	46.06
Picking	81.10	66.37	45.78
Herdsman	53.48	41.32	36.22
Well-digging	116.28	63.47	—
Cane crushing	87.27	61.23	—

**Source:** Labour Bureau, Ministry of Labour and Employment, Government of India, 2010.

**All-India Average Daily Wage Rates in Non-agricultural Occupations during the year 2008-2009 ( Occupation-wise)**

(in Indian Rupees)

<b>Occupation</b>	<b>Men</b>	<b>Women</b>	<b>Children</b>
Carpenter	144.60	—	—
Blacksmith	107.21	—	—
Cobbler	79.59	—	—
Mason	160.30	—	—
Tractor driver	113.13	—	—
Sweeper	63.40	63.42	—
Unskilled labourer (un-specified)	86.43	65.66	42.03

**Source:** Labour Bureau, Ministry of Labour and Employment, Government of India, 2010.

## APPENDIX C

### **WILDLIFE (Protection) ACT, 1972**

#### **[Amendment Act, 2002]**

- An offence involving a species listed in Schedule I or Part II of Schedule II, or an offence committed within a sanctuary or natural park, attracts a mandatory prison term of 3 years, which may extend to 7 years. Mandatory fine of INR.10,000. For subsequent offence, the prison term remains the same, mandatory fine of at least INR.25,000.
- An offence committed inside the core area of a Tiger reserve, attracts a mandatory prison term of 3 years, extendable to 7 years and a fine of INR.50,000 extendable to INR.2 lakhs. In case of subsequent conviction of this nature, there is an imprisonment of at least 7 years and a fine of INR.5 lakhs which may extend to INR.50 lakhs.

**Source:** Ministry of Environment and Forests, Government of India.

## APPENDIX D

### Killing of Tiger through Poaching and Seizure in India 1994-2011

<b>Year</b>	<b>Poaching And Seizures</b>
1994	95
1995	121
1996	52
1997	88
1998	39
1999	81
2000	52
2001	72
2002	46
2003	38
2004	38
2005	46
2006	37
2007	27
2008	29
2009	32
2010	30
2011	13
<b>TOTAL</b>	<b>936</b>

**Source:** Wildlife Protection Society of India, 2011.

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