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Research on Suppression Measures for Illegal Trade in Wildlife Based on Change Theory

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Abstract. The global illegal trade in wildlife is flourishing, causing serious consequences for biodiversity and communities. According to the International Criminal Police Organization, wildlife crime has become one of the largest and most valuable illegal activities in the world. This illegal trade has caused serious damage to biodiversity and communities, putting many species on the brink of extinction. To address this issue, this article proposes a series of response measures based on the theory of change: strengthening the suppression of illegal behavior, increasing management incentives, reducing the cost of coexisting with wildlife, and supporting alternative (non wildlife dependent) livelihoods. Within the framework of change theory, local communities are seen as key drivers of change. Through in-depth comparative analysis, selected case studies, and detailed data cross referencing, this article has gained a deeper understanding of the appropriateness of involving local communities in these change pathways and elaborated on the basic assumptions. In the specific practice of change, this study selected regulators (local communities) and regulated individuals (wildlife traders) as participants in the game, and constructed a Bayesian game model to study the strategic interaction between the two parties. Through this model, this article analyzes pure strategy Nash equilibrium and mixed strategy Nash equilibrium, and obtains the return matrix under different scenarios. The research results indicate that for regulatory agencies (local communities), controllable variables include penalties for misconduct by regulatory agencies (F1), penalties for trader violations (F2), and regulatory costs (C) (where F1 and F2 are completely controllable, and C is partially controllable, depending on the level of regulation). By adjusting these variables F1, F2, and C, illegal wildlife trade can be effectively reduced, thereby achieving sustainability and controllability.

Keywords: Illegal Wildlife Trading; Change Theory; Local Communities; Bayesian Game Models.

1. Introduction

Illegal wildlife trade (IWT) affects a wide range of species, ecosystems, and human societies [1,2]. IWT can cause direct and indirect harm to targeted and non-targeted species, loss of ecosystem services, serve as a conduit for potentially invasive species and a pathway for zoonotic diseases, and disrupt and undermine the local and global economy [3]. It is a lucrative illegal activity: estimates range from $7 billion to $23 billion per year, excluding logging and fisheries. IWT infiltrates the Tree of Life-animals, fungi, plants, and their parts and derivatives are traded worldwide for use as food, fuel, buildings and furniture, pets, medicines, decorations, or religious ceremonies [4], There is no 'one-size-fits-all' strategy to address the IWT problem, as the scale and drivers of the trade are diverse, ranging from basic livelihoods for local communities to highly profitable international business. Any response requires a variety of disciplines and actors to be effective and to ensure the persistence of native species, ecosystem function and human well-being.

Responding to the IWT and mitigating its impacts requires complex, multidisciplinary strategies at global, national and local levels to address a wide range of challenges. Laws may be inadequate, lack data, ignore relevant science, or be poorly enforced; furthermore, "legal trade" does not necessarily mean "sustainable production" or "sustainable management". There is concern that in many cases sustainable trade is difficult to achieve, especially given the systematic lack of scientific data on the status of wild populations and/or the impacts of trade. Therefore, there is a need to develop an appropriate program to reduce IWT [5].The size of the circular sector indicates the proportion of major wildlife species traded in each category (data from CITES Trade Database, https://trade.cites.org/). Between 2007 and 2016, the number of legal imports of amphibians in China was extremely low, with the total number of legal imports of WOEs during the 10-year period being less than 3,000.

2. Research on reducing IWT

"Pathway to change" for reducing IWT through different forms of community engagement and give the underlying assumptions on which each step in these pathways is based, thus helping to devise effective ways of engaging communities in tackling IWT[6].

2.1. The Concept of Theory of Change (TOC)

Theory of Change[7] (TOC) is a methodology or standard used for planning, engagement, adaptive management, and evaluation, a theory of change defines long-term goals and maps them backward to identify necessary prerequisites. TOC explains the process of change by outlining the cause and effect relationships of efforts: short, medium and long term outcomes. Identified changes are mapped into "outcome paths" that show the logical relationship of each outcome to all other outcomes, as well as time sequences and feedback loops. The linkages between outcomes are explained by "rationality", explaining why one outcome is considered a prerequisite for another. The innovations of TOC are:

(1) the distinction between desired and actual outcomes.

(2) Stakeholders can model desired outcomes before deciding on the form of intervention to achieve them.

In the field of conservation and community development, TOC is widely used as planning and evaluation tools because they provide a useful framework for setting and evaluating goals and objectives:

Specific activities carried out by institutions such as non-governmental organizations (NGOs) or government departments.the change in behavior that occurs as a result of the output,changes in the target environment or social factors.

2.2. Who is appropriate to engage in TOC to reduce IWT?

Involving local communities is recognized as a key approach to tackling the IWT.Local communities inhabit environments that are symbiotic with wildlife and have a deep understanding of local species, ecosystems and cultures[8]. This local knowledge is key to developing effective responses, as local knowledge can help identify potential illegal trading points and protect priority species.Local communities understand how local resources are distributed and used, and they can effectively utilize their own resources to implement the theory of change. This includes resources for monitoring and combating illegal activities, such as employing local staff, setting up monitoring points and training local volunteers.Because the illegal wildlife trade often directly affects local communities, they have a greater incentive to get involved in stopping the problem. By creating a theory of change based on local communities, it is possible to increase the sense of engagement of community members and motivate them to take more active action. Additionally, this sense of engagement helps to ensure that the measures taken are sustainable, as local communities are more likely to be invested in the solution over the long term.Local communities are often more aware of local culture and traditional practices, which is crucial for developing a theory of change that is aligned with local community values. By respecting and integrating local cultures, a reduction in illegal wildlife trade can be better promoted, while protecting and maintaining traditional local ecosystems.Local communities often have more control over local affairs. By decentralizing the implementation of the Theory of Change to the local level, the challenge of illegal wildlife trade can be addressed more flexibly and policies can be implemented more effectively.Local communities can benefit from legal alternatives to illegal wildlife trade, motivating them to actively participate in the Theory of Change. For example, the development of sustainable eco-tourism and local handicraft industries allows community members to generate income from the illegal trade.

2.3. Why involve the local communities?

It is well known that there is no simple solution to the problem of IWT. Over the past few years, a wide range of approaches have been emphasized and adopted in a series of international policy statements, initiatives and coalitions, they can be broadly categorized into three types.

(1) Strengthening law enforcement and reinforcing criminal justice systems at all stages of the value chain, including the procurement, trafficking and consumption stages.

(2) Reducing demand consumption of illicit products.

(3) Supporting sustainable livelihoods and local economic development.

To date, most attention has been focused on the first two approaches, with relatively limited attention paid to the third. For example, the 2014 European Parliament resolution on wildlife crime included more than 30 wide-ranging actions to support enforcement, from strengthening intelligence, enforcement and judicial systems to introducing trading moratoriums and revising penalties. In contrast, only one action was targeted at local communities - the promotion of alternative (non-wildlife-based) livelihood strategies.

IWT has had a huge impact on the communities that share their lives with wildlife. This includes communities that have wildlife on land under their control, as well as those living near wildlife reserves (e.g. national parks). These communities are affected by insecurity and the depletion of important livelihoods and economic assets. They may also be affected by heavy-handed militarized responses to wildlife crime. Law enforcement systems often make little distinction between illegal activities driven by huge profits ("criminal greed").

Most fundamentally, however, the long-term survival of wildlife populations, and in particular the success of interventions to combat the international wildlife trade, depends to a large extent on the local communities with which wildlife populations live. If wildlife populations bring economic and social value to people, local people will have an incentive to support and participate in efforts to combat and manage poaching and illegal trade. However, if local people do not play a role in wildlife management, and if wildlife management does not bring them any benefits, the incentives to utilize wildlife illegally will be very strong. (as well as the conversion of land to agriculture, which is a much greater threat to most species than the IWT). Even the most focused and well-resourced law enforcement efforts have difficulty effectively controlling wildlife crime because of the strong incentives for local people to be complicit. Fig 1 shows the Potential impacts of interventions to combat IWT on incentives facing local community members. Dotted lines indicate more speculative impacts.

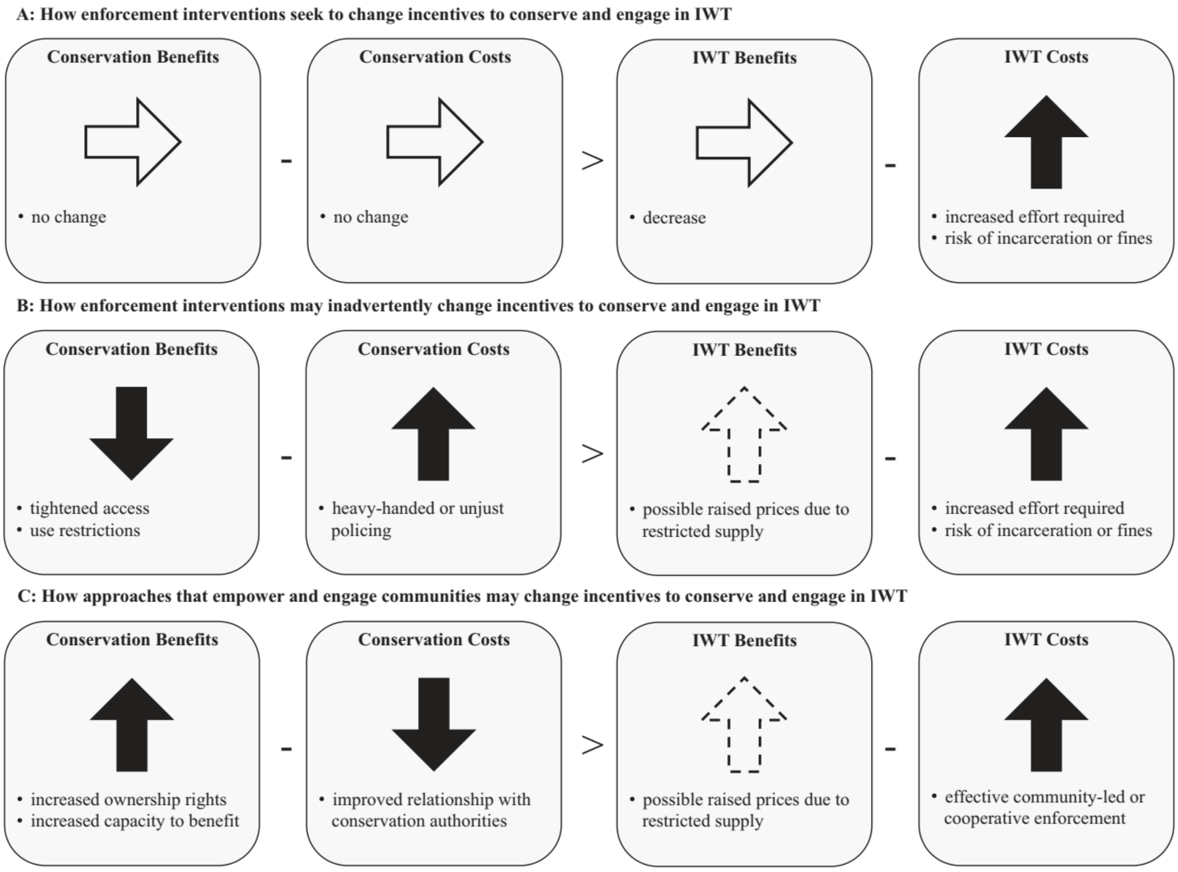

Fig. 1 Potential impacts of interventions to combat IWT on incentives facing local community members. Dotted lines indicate more speculative impacts

The international community is increasingly recognizing the need for community engagement. a major intergovernmental conference on illegal trade in wildlife in February 2014 produced the London Declaration (which recognizes the African Elephant Action Plan and urgent measures endorsed by the African Elephant Summit in December 2013), which includes a series of commitments to strengthen the role of local communities - as do other international declarations. In conjunction with the London Conference on Illegal Trade in Wildlife: United for Wildlife, a coalition of international conservation organizations convened by the Royal Foundation, hosted a two-day conference to explore "International Wildlife Trafficking: One of the solutions to the illegal trade in international wildlife declared by United for Wildlife is a successful model for supporting community-based wildlife management." The Kasane Conference on Illegal Trade in Wildlife (held in March 2015) and the Common Strategy to Combat Illegal Trade in Wildlife in Africa (developed at an international conference in Brazzaville in April 2015) also highlighted the importance of recognizing the rights of local people to benefit from wildlife conservation.

2.4. Underlying assumptions of local community participation in TOC

The proposed theory of change for engaging local communities in combating illegal wildlife trade has four pathways of change:

A. Strengthening disincentives for illegal behavior, which includes making it more difficult and costly to trade in poached wildlife.

B. Increasing incentives for stewardship, a pathway that includes strengthening economic and non-economic incentives for the conservation and sustainable management of wildlife.

C. Decrease costs of living with wildlife, a pathway that involves reducing the burden of coexistence with wildlife.

D. Supporting alternative(non-wildlife-based) livelihoods, this pathway involves creating non-wildlife trade livelihoods.

The logical chain (black arrows) is that actions lead to outputs, and outputs lead to outcomes and overall expected impacts. Enabling actions reinforce all actions and provide favorable conditions. The assumptions behind each step in the logic chain are indicated by white letters in the black arrows. Green arrows indicate feedback.

2.5. Bayesian game analysis after local communities engagement

2.5.1. Game Model Selection and Construction

2.5.1.1. Assumptions and description of game model

Analyzing the current situation and characteristics of illegal wildlife trade, the game is a static game because the local community and illegal wildlife traders should act and make decisions at the same time from the perspective of the order of action [9,10]. At the same time, the local community does not know the trader's revenue situation, the trader is not clear about the regulatory cost of regulating the local community, the two sides of the game do not fully understand each other's revenue function, which should belong to the game of incomplete information. Therefore, the illegal wildlife trade game belongs to the incomplete information static game, also known as Bayesian game, and the corresponding equilibrium solution is Bayesian Nash equilibrium.

(1) Participants

Regulators are local communities and traders are the various groups of people engaged in illegal wildlife trade. Both are "rational beings" and the "rational being" is "common knowledge".

(2) Purely strategic choices

For regulators, the pure strategic choice is to regulate or not to regulate; for traders, the pure strategic choice is to trade in illegal wildlife or not to trade in illegal wildlife.

(3) Payment function hypothesis

For the regulator, regulation entails an opportunity cost C, the larger value of which indicates a greater regulatory effort or a higher regulatory cost. If the regulator does not regulate, then its payment cost is zero. However, if the trader engages in illegal wildlife trade (Assuming that the trade will come to light sooner or later), the regulator will be penalized by F1 (F1 > 0), which is a measure of the total cost of malpractice (e.g., removal from office, fines, legal sanctions, etc.) to the local community.

For the trader, when he engages in illegal wildlife trade, he makes an economic profit R, but if he is discovered (Assuming that the trade is exposed sooner or later) he is penalized F2 (F2 > 0). F2 is understood as a measure of the total price he pays for engaging in the illegal wildlife trade (both the costs incurred and the penalty). It is assumed that the economic profit when he refuses to engage in illegal wildlife trade is 0. Such an assumption is reasonable both to account for the difference in the trader's benefits under the two strategies and to facilitate analysis. The benefit matrix at this point is shown in Fig 2.

		Trader	
		No illegal wildlife trade	Engaging in illegal wildlife trade
Local communities	Regulate	$-C, 0$	$-C, R-F_2$
	Unregulated	$0, 0$	$-F_1, R$

Fig 2. Pay-off matrix(a)

2.5.1.2. Game Modeling & Equilibrium Analysis

In the IWT game, if a trader or a regulator choSince the local community (the regulator) and the traders (the regulated) are the two sides of the game, they constitute a static game with incomplete information. If *G* is used to represent a game with *n* players, the set of all available strategies of each player is called the "strategy space", respectively, denoted by $S_1,\cdots,S_n$. $S_{ij}\in S_i$ denote the *j*th strategy of player *i*, where *j* can take a finite number of values (finite-strategy game) or an infinite number of values (infinite-strategy game). The benefit of game party *i* is denoted by U_i, which is a multivariate function of the strategies of each game party. *n*-party game *G* is often written as $G=\{S_1,\cdots,S_n;U_1,\cdots,U_n\}$. In the game *G*,, if in a strategy combination $(S_1^*,\cdots,S_n^*)$ consisting of each strategy of each player, the strategy S_1^* of any player *i* is the best response to the strategy combination $(S_1^*,\cdots,S_{i-1}^*,S_{ij},S_{i+1}^*\cdots,S_n^*)$ of the remaining players, i.e., $U_i(S_1^*,\cdots,S_{i-1}^*,S_i^*,S_{i+1}^*\cdots,S_n^*)\ge U_i(S_1^*,\cdots,S_{i-1}^*,S_{ij},S_{i+1}^*\cdots,S_n^*)$, if it holds for any $S_{ij}\in S_i$, then it is called a "pure strategy Nash equilibrium" in *G*. The pure strategy Nash equilibrium can usually be solved by using the benefit matrix to represent the benefits of each player under different strategies. In the game *G*, assume that participant *i* has *k* pure strategies: $S_i=\{S_{i1},\cdots,S_{ik}\}$, then the probability distribution $\sigma_i=(\sigma_{il},\cdots,\sigma_{ik})$ is called one of *i*'s mixed strategies, where $\sigma_{ik}=\sigma(S_{ik})$ is the probability that *i* chooses S_{ik} , for all *k*, $0\le\sigma_{ik}\le 1,\sum_1^k\sigma_{ik}=1$.

Noses only one particular action given information, such as engaging in illegal wildlife trade or not engaging in illegal wildlife trade, regulating or not regulating, the strategy is said to be a pure strategy. Conversely, if the trader or regulator chooses different actions randomly with some probability distribution, the strategy is said to be a mixed strategy. In a static game, a pure strategy is equivalent to a specific action, and a mixed strategy is a random choice between different actions.

2.5.2. Game model solving

On the basis of constructing a Bayesian game model, its pure strategy and mixed strategy Nash equilibrium solutions are sought respectively, and the game analysis is carried out.

2.5.2.1. Pure strategy Nash equilibrium analysis

Assuming that C > 0, R > 0, F1 > 0, F2 > 0, it can be concluded that the desired outcome of "no regulation by the local community and traders do not engage in illegal wildlife trade" is not a Nash equilibrium outcome. That is to say, the situation that traders refuse to engage in illegal wildlife trade without the regulation of the local community does not exist due to the profit motive. For the local community, as long as there is a regulatory cost C, the suboptimal outcome "the local community regulates and traders do not engage in illegal wildlife trade" is also not a Nash equilibrium outcome. This suggests that it is theoretically impossible to completely eliminate illegal wildlife trade by traders solely by relying on the system, unless the cost of regulation is equal to zero and there are no loopholes in the regulation, which is clearly impossible. The matrix analysis is shown in Fig 3.

		Trader	
		No illegal wildlife trade	Engaging in illegal wildlife trade
Local communities	Regulate	$-C,0\downarrow$	$-C,R-F_2$
	Unregulated	$0,0\rightarrow$	$\theta,R-F_2$

Fig 3. Pay-off matrix(b)

The four scenarios of the benefit matrix (b) are analyzed below.

(1) If C > F1 and R > F2, then there is a unique Nash equilibrium outcome, which is that "traders engage in wildlife trade if regulators do not regulate". This indicates that for the regulator, if it is difficult to regulate or the cost of regulation is high, and the penalty for malfeasance caused by non-regulation is relatively small, the regulator will choose not to regulate according to its own interest

maximization; for the trader, engaged in the trade of wildlife is more profitable, and the penalty for this illegal act is relatively small when it is discovered, he will certainly choose to engage in the trade of wildlife. This is also confirmed by the fact that most of the wildlife trade incidents occur in rural areas. This is because the high cost of regulation in rural areas makes regulation ineffective. The equilibrium results are analyzed in Fig 4.

		Trader	
		No illegal wildlife trade	Engaging in illegal wildlife trade
Local communities	Regulate	$\rightarrow -C, 0 \downarrow$	$-C, R-F_2 \downarrow$
	Unregulated	$0, 0 \rightarrow$	$-F_1, R$

Fig 4. Pay-off matrix(c)

(2) If C < F1 and R > F2, then there is a unique Nash equilibrium outcome, "regulators regulate and traders engage in wildlife trade". This suggests that after the regulator discovered the illegal behavior of the traders and punished them, because the punishment is not strong, or the traders still have a large profit after accepting the punishment, then the traders will choose to continue to engage in wildlife trade, resulting in the failure of the regulation, the wild animals are as hard to escape the fate. The analysis of the equilibrium results is shown in Fig 5.

		Trader	
		No illegal wildlife trade	Engaging in illegal wildlife trade
Local communities	Regulate	$\rightarrow -C, 0 \downarrow$	$-C, R-F_2$

Fig 5. Pay-off matrix(d)

(3) If C > F1 and R < F2, then there is a unique Nash equilibrium outcome, "the regulator does not regulate and the trader engages in wildlife trade." This means that although the trader faces a higher penalty than he would gain from violating the law (R < F2), he still engages in wildlife trade for economic profit R (R > 0) because he has predicted that the regulator will forego regulation (because in this case the regulator's cost of regulation is too high, and because he will not face a more severe penalty for malfeasance). At this point, the penalty for the trader becomes an "implausible threat". The equilibrium results are analyzed in Fig 6.

		Trader	
		No illegal wildlife trade	Engaging in illegal wildlife trade
Local communities	Regulate	$-C, 0 \downarrow$	$\leftarrow -C, R-F_2 \downarrow$
	Unregulated	$0, 0 \rightarrow$	$-F_1, R$

Fig 6. Pay-off matrix(e)

(4) If C < F1 and R < F2, then there is no pure strategy Nash equilibrium. The analysis process is shown in Fig 7. This shows that although we cannot eliminate 100% of the illegal behaviors of traders, the paper at least guarantee that traders will not engage in wildlife trade 100% of the time, or that traders can only engage in wildlife trade with a certain probability.

		Trader	
		No illegal wildlife trade	Engaging in illegal wildlife trade
Local communities	Regulate	$-C,0\downarrow$	$-C,R-F_2\leftarrow$
	Unregulated	$0,0\rightarrow$	$\uparrow -F_1,R$

Fig 7. Pay-off matrix(f)

3. Conclusions

The scale of the threat of the illegal wildlife trade, with its enormous negative impact on the environment and global biodiversity, is alarming. It is estimated that this illegal trade involves as much as $26.5 billion annually, making it the fourth largest illegal trade globally. In response to this problem, this paper proposes a series of pathways to change based on the theory of change, each of which is based on underlying assumptions. These pathways aim to strengthen disincentives to illicit behavior, incentivize stewardship, reduce the costs of coexistence, and support alternative livelihoods. By transparently mapping the logical pathways of these pathways, the paper are able to more effectively plan actions and interventions to achieve the desired change.

Local communities are considered suitable participants in this pathway of change because community members have a deeper understanding of local ecosystems and wildlife conservation. Community participation not only helps to reduce illegal trade, but can also create more sustainable patterns of coexistence. The involvement of community members is not just a responsibility, but an opportunity to make this process of change deeper and more comprehensive.

To better understand the strategic process of community participation, we introduce a Bayesian game model. By analyzing the strategic choices of participants, we are able to predict and assess the behavior of each party and provide a theoretical basis for program adjustments. The strategic analysis not only reveals the motivations of the participants, but also provides insights for developing more effective responses.

Finally, through a sensitivity analysis of the model, we were able to draw stable and feasible conclusions about the next five years. These conclusions not only provide direction for the long-term planning of the project, but also provide confidence to community members and stakeholders, demonstrating the feasibility and potential success of the change pathway.

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