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Economic loss to chickens' farmers caused by invasive Indian house crow (*Corvus splendens*) predation in Dodoma, Tanzania

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Abstract

Corvus splendens, also known as the Indian house crow (IHC), is an invasive bird species introduced to Zanzibar from India. It has become widespread throughout the Tanzania regions, particularly in Dodoma Urban. However, there has been limited research on the broader effects of predation on chickens.In Dodoma, Tanzania, Indian house crows (*Corvus splendens*) are known to prey on chicks, causing significant financial hardship for poultry owners. This study aimed to investigate the monetary losses incurred due to crow predation across various chicken age groups and seasonal variations. A semi-structured qualitative questionnaire survey was conducted to gather information from 403 farmers in the wards of Makulu, Makole, and Ndachi, with Makulu and Makole identified as the urban and peri-urban areas of the wards, respectively. The collected data were then analyzed using Kruskal-Wallis statistical tests and a Generalized Linear Model.Farmers reported higher predation rates by Indian house crows on chicks and eggs compared to other age groups of chickens. Chicks and eggs were found to be more vulnerable and less capable of defending themselves against predation, resulting in a substantial economic loss of 27,739.64 Tsh (1.21 USD) per farmer per year. Economic losses were further analyzed across different seasons, revealing the months of April to August experienced the highest predation rates per year per farmer compared to other seasons ($P<0.005$). In conclusion, highlighting potential ramifications for poultry management and conservation efforts in Dodoma and analogous regions would offer readers crucial insights. This study emphasizes the adverse effects of Indian house crow predation on chicken populations, resulting in substantial economic losses for poultry farmers in Dodoma. An in-depth understanding of crow predation dynamics can inform the formulation of strategies to safeguard poultry and mitigate economic losses in the region.

Keywords: Indian house crow, Economic loss, Human wildlife Conflict, Livestock keeper

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1. Introduction

The paper focuses on investigating the economic repercussions of predation by the Indian House Crow on local chicken farming in the Dodoma region. The Dodoma region is predominantly inhabited by livestock keepers engaged in goat, cattle, and chicken farming (Ngongolo & Chota, 2021, 2022a). The chicken farming sector in Dodoma faces various challenges, including diseases, predation, theft, limited space, a lack of experts, inadequate chicken housing, and insufficient feed (Ngongolo & Chota, 2022a).These challenges outweigh the benefits provided by the chicken farming sector in the area, such as meat, manure, a source of income, offerings, provision of school fees, aesthetic value (beauty), and a source of employment (Ngongolo et al., 2021).

Despite predation being highlighted as one of the challenges in Dodoma, there is limited information available on the specific predators and the economic losses they cause to farmers. A previous study in Dodoma indicated that the economic loss caused by diseases per year was approximately Tsh. 119.9 million (52,146.96 USD) for 400 households, equivalent to 130.37 USD per household (Ngongolo & Chota, 2022a). However, no study has been conducted to understand the economic losses caused by predators, specifically the Indian House Crow to chickens kept by farmers.

The Indian house crow negatively affects local ecology by disrupting ecosystems, poses challenges for farmers through poultry predation, and impacts society with economic losses and health concerns. In New Zealand, suitable habitat encourages house crow invasion, causing adverse effects on the ecosystem (Fraser et al., 2015). Khera et al. (2010) found that house crows, thriving near coasts, impact livestock production and agriculture. Globally, Johan et al. (2022) reported that house crows transmit diseases, posing risks to avian and human health. In Tanzania, particularly in Dodoma, further studies are needed to understand its impact on agriculture, livestock, and the ecosystem.

In recent years, the increase in Indian House Crow populations has raised concerns among farmers, and their predation activities have become a focal point. The research conducted in the villages of Limpopo Province, South Africa, revealed that predation significantly impacted chicks, affecting hens at a rate of 67%, followed by cocks at 63%(Ndlovu et al., 2021). Common predators identified included snakes, such as the king cobra (*phakhuphakhu*), birds like the martial eagle (Goni), and wild animals, particularly the genet cat (tsimba) (Ndlovu et al., 2021).There is a need to investigate the predation effects to farmers keeping local chicken in Dodoma specifically the impact of Indian house crow which has been observed to be found in the Dodoma. Another stud revealed that, the Indian house crow can harbor pathogens and parasites which affects chickens. The parasites and pathogens reported includes; Lice, *Escherichia coli, Proteus spp* and Coccidiathat can potentially, cause diseases in chicken(Cooper, 1996). However, in this study, they did report the effects of Indian house crow as predators to chicken.

Poultry farming serves as a crucial income source and nutritional reservoir, contributing to food security in the region. However, the escalating predation by the Indian house crow jeopardizes the sustainability of this essential economic activity. This study focused at assessing the annual economic loss caused by the Indian house crow to the farmers who are keeping chicken in Dodoma. In addition, the study will highlight the control strategies used by the farmers to overcome the challenge of predation by Indian house crows to their chicken in Dodoma.

2. Materials and Methods

2.1 Study area

The research was conducted in Dodoma Municipal within Dodoma Region, spanning from January 2022 to December 2022. Dodoma is one of the regions in Tanzania. The study area was divided into two primary sections: peri-urban and urban areas. The peri-urban focus was on Ndachi, situated away from the city center, while the urban areas encompassed Makole and Makulu wards located within the center of Dodoma Municipal.

2.2 Vegetation types

The natural landscapes of Dodoma exhibit wooded regions, expansive grasslands, and minimal tree or brush coverage. The ground in Dodoma is characterized by forested grasslands and thickets of bushes, with the latter being leafless and dry during the dry season but transforming into vibrant greenery during the rainy season (Kayombo et al., 2020). Woodlands cover a significant portion of the terrain, particularly in hilly areas, creating a landscape of dry savanna shrub-thicket regions interspersed with scattered trees and patches of grassland interrupted by trees and shrubs. Indigenous plant species, such as *Busseamassaiensis, Commiphora coerulea, and Acacia tortilis,* coexist with exotics like *Peltophorum pterocarpum* and *Tamarindus indica* (Kayombo et al., 2020). This is supported by climatic condition of Dodoma region which is semi-arid climate with warm to hot temperature throughout the year and 605mm of rainfall per year. The socio-economic activities which can be seen in an area includes the agriculture, livestock keeping, business, and others like beekeeping, fishing and aquaculture farming, and government official activities.

2.3 Study design

A combination of cross-sectional and longitudinal surveys was utilized for data collection. The cross-sectional study involved gathering information from farmers in a single instance. The questionnaires were designed to longitudinally capture data throughout the year. In each study ward, chicken keepers were identified, and checklists were prepared in collaboration with local government leaders. The sample size, determined using Slovin's formula with a 95% confidence level, 5% margin of error, and an assumed population proportion of 0.5, accounted for an unlimited population size, with a corresponding z-value of 1.96.

The formular used for calculation was as follows for unknown population of people who are keeping chicken in the area. $N = [z^2xp\ (1-p)]/e^2$. Whereby; z = z-score, e = margin of error, p = standard of deviation. In this case, the required sample size for this study was at least 384.16 (Approximately will be 384 sample size)(Israel, 1992; Wikihow, 2023). For this study, each ward was anticipated to have at least 192 samples from each ward (making a total of 386 samples).

3. Data collection

A semi-structured questionnaire was employed to collect information from respondents, consisting of both open and closed questions, with Likert scaling included in some sections. Under Likert scaling, sentences were formulated, and respondents were required to rank them based on appropriateness and their perceptions of the statements. Rankings ranged from 1 to 5, with 5 indicating strong agreement and 1 indicating strong disagreement. The collected data encompassed the demographic profile of respondents, awareness of the Indian house crow as a predator challenging chicken flock, the number of chickens preyed upon in each quarter of the year(Q1=January-March, Q2=April-June, Q3=July-September, Q4=October-December), and the categorization of predated chickens by age and sex (Hen, Cocks, Pullet, Cockerel, and Chicks). This facilitates the collection of information throughout the year (longitudinally). In each quarter, the information gathered included the number of chickens predated for each category, factors affecting predation rates, and the strategies employed by farmers to overcome these challenges. Additionally, market prices for each chicken class were surveyed for estimating the financial loss caused by Indian house crow predation. Chicken losses and corresponding costs were calculated for each quarter, facilitating a comprehensive comparison of financial losses throughout the year. The study also investigated the strategies employed by farmers to mitigate the challenge of Indian house crow predation on their chickens.

4. Evaluating Economic Losses Incurred by Farmers Due to Indian House Crow Predation on Chickens

To quantify the economic impact on chicken farmers, we initially assessed the number of chickens predated by Indian House Crows (IHC) in each quarter of the year (Q1=January-March, Q2=April-June, Q3=July-September, Q4=October-December) for various chicken groups (Hens, Cocks, Pullets, Cockerels, and Chicks). Next, we determined the selling price for each chicken category during the sampling year. Finally, we calculated economic losses by multiplying the quantity lost in each category by its corresponding price.

The formula for economic loss due to predation was as follows:
Economic Loss (Tsh)=(Hen Lost×Price per Hen)+(Cocks Lost×Price per Cock)+(Cockerels Lost×Price per Cockerel)+(Pullets Los t×Price per Pullet)+(Chicks Lost×Price per Chick)+(Eggs Lost×Price per Egg)

This adjusted formula maintains clarity and conciseness while providing a more structured representation of the economic loss calculation.This model allowed us to evaluate losses quarterly and annually.

5. Data analysis

Categorical data, demonstrating independence with random sampling, expected frequency, and mutual exclusivity where each observation falls into only one category, underwent analysis using the chi-square statistical test. Additionally, to examine the variation in the number of chickens predated by Indian house crows across the four seasons, the Kruskal-Wallis statistical test assessed significance. Furthermore, to comprehend the influencing factors on the number of predated chicks, a generalized linear model was employed. The level of significance was set at p=0.05; a p-value less than 0.05 indicated significance. The generalized linear model (GLM) was utilized to evaluate the association between predated chickens and other factors such as age, predator abundance, and season.Statistical analysis was performed using PAST 3.04 statistical package (Hammer& Harper,2001).

6. Results

6.1 Demographic structure of respondents

During the questionnaire survey in the study area, a total of 403 individuals were interviewed. Among them, 54.59% (n=220) of respondents were from peri-urban areas, and 45.41% (n=183) were from urban areas. In terms of gender, 64.52% (n=260) were female, and 35.48% (n=143) were male. The family size ranged from 1 to 10 individuals. The demographic structure exhibited significant differences between urban and peri-urban areas. Notably, a moderate family size of 4-6 members was predominant in both study sites. Furthermore, in terms of occupation, the self-employed were more prevalent in peri-urban areas compared to urban areas (Table 1).

Table 1. Demographic structure of respondents in the study area

S/No	Item	Classification	Peri-urban	Urban	Chi Square	P-value
1	Sex	Male	39	104	68.008	1.63E-16
		Female	182	78		
2	Family Size	Small (1-3)	52	13		
		Moderate (4-6)	156	143		
		Large (7-10)	13	26	24.76	4.21E-06
3	Age group (Years)	Young (12-30	91	26		
		Adult (31-50)	104	130	35.556	1.89 E-08
		Old (51 and above)	26	26		
4	Education level	Primary	169	117		
		Secondary	52	13	81.85	1.69E-18
		University/college	0	52		
5	Occupation	Employed	13	65	455.09	3.94E-95
		Self employed	208	91		
		Business	0	26		
6	Marital Status	Single	39	13	53.66	1.329E-11
		Married	182	156		
		Widow	0	13		

6.2 Awareness on Indian House crow

It was noted that all respondents, both in urban and peri-urban areas, were conscious of the existence of Indian house crows in their surroundings. The average count of Indian house crows observed per hour in their vicinity was recorded as (Mean=7.32±0.20, n = 403). When comparing urban and peri-urban settings, a statistically significant disparity was found, with a higher count of Indian house crows reported in the urban area (Mann-Whitney U = 7351.5, P=0.0001) (Figure 1).Also, in urban areas, predation was more prevalent across all four quarters of the year compared to peri-urban areas (Figure 2).

Approximately 77.42% (n=312) indicated that their chickens had encountered predation by Indian house crows, while 22.58% (n = 91) reported no such incidents. The average number of chickens preyed upon per year per farmer was recorded as 17.03±0.95 chickens. The highest predation rate was observed in Quarter 2 (approximately 6 individuals), followed by Quarter 3 (approximately 5 individuals), Quarter 4 (4 individuals), and the lowest in Quarter 1 (approximately 3 individuals)(Kruskal-Walli's test=101.2, P=8.647E-22).

For instance one of the respondents said *that " .....Indian house crow have stilled the eggs where my hen are laying……"* while another respondent reported saying that *"……The Indian house came in team and captured chicks, they are great cause of loss in my chicken proctuction....."*

Figure 1. The Average number of Indian House crow seen per hour in Urban and Peri-urban

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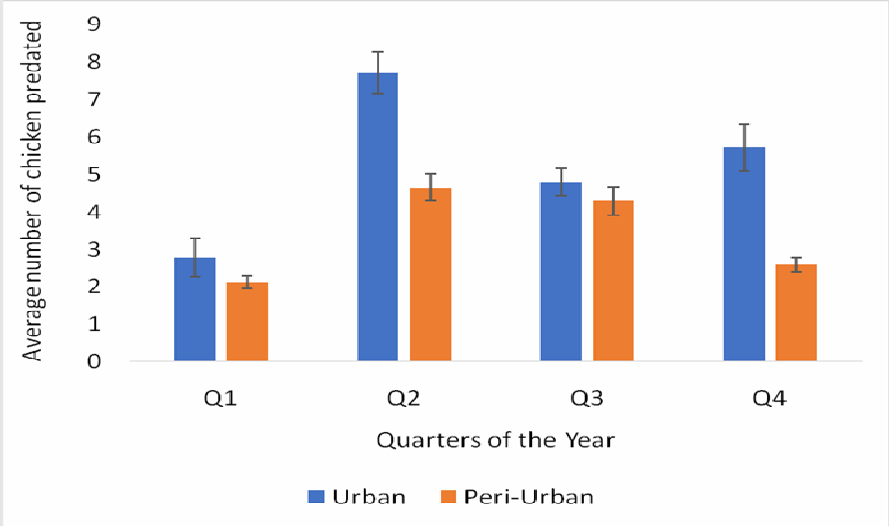

Figure 2. Average number of chickens predated for both Urban and peri-urban areas across the four quarters of the year (Q1, Q2, Q3 and Q4)

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6.3 Economic loss caused by Indian house crow o chicken farmers

Based on 403 respondents, the average selling price of chicken at different age and sex was 20000±0., 17221.95±135.14, 4178.30±26.66, 5532.45±362.23, 1437.66±15.65 and 496.76±0.89 Tsh. For cock, hen, pullet, cockerel, chicks and eggs, respectively. From a total of 403 respondents, a total of 6889 individuals were predated by Indian house crow in the year 2022. Of these, 4.15%, 3.38%, 85.29% and 7.17% were attributed from pullet, cockerel, chicks and eggs respectively. These yielded a total economic loss of 11,179,070Tsh (4,860.47 USD). This was equivalent to 27,739.64Tsh (1.21 USD) loss per farmer per year. Regarding the age and sex group of chicken, financial loss was reported in chicks specifically that are found in peri-urban (Figure 4). However, the difference between urban and per-urban in terms of economic loss was observed to be insignificant (Mann-Whitn U=12, p=0.37).

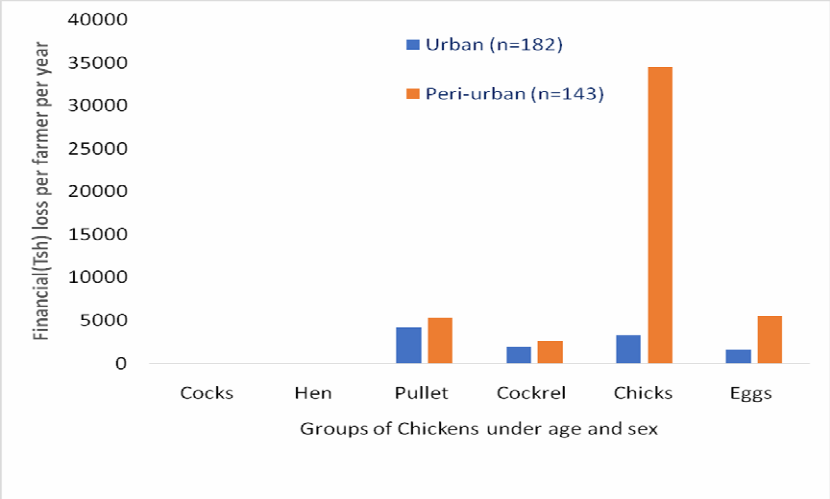

Figure 4. The financial caused by predation in chicken in urban and peri-urban areas across the sexes and age group per framer per year

6.4 Strategies used by farmers to overcome the challenges of Indian predation to chicken

Different methods were reported to be employed by the farmers to overcome the challenge predation of Indian house crow to chicken. The mostly used method by farmers was protecting chicken through locking, followed by chasing and shouting (Table 2). The perception of farmers in Urban and peri-urban on the control strategies used to overcome the challenges was statistical insignificant (Table 1). Poisoning was not indicated as means of overcoming the challenge. One of the farmer was reported saying *"…..we fail to use poison in controlling chicken predation by Indian house crow due to expenses involved in purchasing the poison……..."* Also, one of the key informants said that, "……. *another appropriate method the farmers can apply is painting the chick, this will make them unseen with the predator (Indian house crow……."*

Table 2. Different methods used by farmers to overcome the challenges of predation of Indian house crow to their chicken

S/No.	Method Used	Urban	Per-urban	Overall	Ranking
1	Chasing	143	169	312	2
2	Shouting (making Noise)	78	52	130	3
3	Trapping	0	26	26	5
4	Poisoning	0	0	0	6
5	Protecting chicken Through Locking	182	195	377	1
6	Catapult (Manati)	13	23	36	4
7	Mann-Whitney U	15			
8	P-value	0.69			

6.5 The influence of different factor on the predation success of Indian house crow to chicken

Different factors were observed to influence the predation success of Indian house crow (*Corvus splendens*) to chicken differently. For instance, regarding season, positive influence was observed in the quarter 2 (April and June) and quarter 4 (October to December) while negative association being observed in quarter 1(January-March). (Table 3),

Table 3. The association between the number of chickens predated with other independent variables (factors) specifically abundance of IHC, localities (Urban and peri-urban), season of the year (the four quarters Q1, Q2, Q3 and Q4).

S/No.	Variables	Classification	Coef. Estimate	S. D	z-value	P-value
1	Intercept	(Peri-urban)	-0.11	0.17	-2.89	0.44
2	Abundance	Average number of IHC seen per hour	0.02	0.01	1.88	0.06
3	Localities	Urban	0.18	0.08	2.32	0.02 *
4	Predated chicken	Cocks	N/A	N/A	N/A	N/A
		Hen	N/A	N/A	N/A	N/A
		Cockerel	0.13	0.05	2.98	0.0029 **
		Pullet	-0.41	0.05	-8.56	< 2e-16 ***
		Chicks	0.21	0.02	10.453	< 2e-16 ***
		Eggs	-0.01	0.01	-1.91	0.0566
5	Season (Quarters of the year)	Quarter 1 (Q1)	-0.25	0.03	-8.39	< 2e-16 ***
		Quarter 2 (Q2)	0.12	0.02	5.58	2.35e-08 ***
		Quarter 3 (Q3)	0.001	0.01	0.14	0.89
		Quarter 4 (Q4)	0.18	0.02	8.51	< 2e-16 ***
6	Strategies (Methods) used to overcome the challenges	Chasing	4.915e-01	1.46e-01	3.37	0.000766 ***
		Shouting (Making noise	0.25	0.07	3.69	0.0002 ***
		Trapping	-0.03	0.05	-0.65	0.52
		Poisoning	N/A	N/A	N/A	N/A
		Protecting chicken through locking	1.82e+01	0.075e+02	0.028	0.98
		Catapult (Manati)	1.77	0.15	11.91	< 2e-16 ***

7. Discussion

The predation of Indian house crows (*Corvus splendens*) on chickens kept by farmers is an important factor to consider when raising local chickens in a free-range system in Dodoma, regardless of their socio-economic importance (Ngongolo et al., 2021). Indian house crows, like other predators, contribute to chicken mortality, resulting in economic losses for farmers practicing free-range chicken farming. A study conducted in villages around Serengeti National Park revealed that predators, including Indian house crows, claimed nearly one-third of the poultry owned by each household. This led to an average annual economic setback of approximately US $14.5 ± 18.6, equivalent to 10.4% of the cash income (Holmern & Røskaft, 2013). The issue is expected to escalate in other areas where potential habitats are available, and climate change is anticipated to drive the spread to these localities (Ndimuligo et al., 2022)

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7.1 Economic loss due to Indian House crow predation to chicken

The most vulnerable members of the flock to predation by Indian house crows were found to be chicks and eggs when compared with other age groups of chickens. This correlation aligns with findings reported in Dar-es-Salaam, where the Indian house crow disproportionately affected chicks and eggs (Shimba & Jonah, 2017). The heightened vulnerability of chicks can be attributed to

their smaller size, weaker mobility, and lack of protective feathers, making them easier targets for predators like crows, as observed in various studies.

A comparison between predated chicks and eggs revealed that chicks were more abundantly preyed upon in this study. This observation may be attributed to the fact that eggs are often hidden, while chicks roam freely in a free-range system, making them more susceptible to predation. Research on wader chicks has shown that predation significantly impacts bird reproduction success. The influence of predation varies with the time of day and season, with diurnal predation events being more numerous and nocturnal predation being more intense per hour, mainly due to raptors. Seasonal increases in chick predation suggest higher success rates for breeding attempts that occur earlier in the season (Mason et al., 2018)

In this study, it was evident that the economic loss caused by predation to farmers keeping chickens under a free-range system was 27,739.64 Tsh (12.06 USD) per farmer per year. This loss is expected to escalate if the population of the Indian house crow continues to increase in the area. Another study conducted in Dodoma successfully assessed the economic loss caused by diseases in chickens, amounting to 2.998 million Tsh (1303 USD). However, there was a lack of information regarding the economic loss caused by predation, particularly by the Indian house crow (Ngongolo & Chota, 2022b).Financial losses varied significantly between peri-urban and urban areas. This variance can be attributed to the abundance of Indian house crows, predation rates, and pricing differences between chicks and eggs, possibly causing the variation in economic loss observed between the two. Chicks, being mobile, are more exposed to predators, unlike eggs, which are hidden by the laying hen and the chicken keepers.This study revealed a significant change in predation rates as one moves from peri-urban to urban areas.

7.2 Predation across the four quarters of the years

There was a likelihood of an increase in predation by the Indian house crow in quarters 2, 3, and 4, with a significant reduction in quarter 1. This positive association with predation in these seasons could possibly be linked to the breeding behaviors of the Indian house crow. During these months, the crows require higher energy and protein levels for reproduction and feeding the hatchlings. Concurrently, free-range chickens tend to hatch during these seasons, leading to a higher population of chicks and consequently increasing the chance and number of individuals being preyed upon. This aligns with a study conducted in India, which demonstrated that Indian house crows breed in Ratnagiri and Goa again after rains in November-December, as climatic conditions conducive to crow breeding are duplicated at that time, with temperatures not exceeding 31.2°C. Conversely, findings from Poona indicated that the House Crow breeds only once a year in April-May when the mean maximum temperature ranges from 37.5°C to 39.4°C (Lamba, 1977). Additionally, a study in South Africa revealed that egg-laying occurs from October to January, mainly mid-October to the end of November, which falls within quarter 4 (Q4) (Allan & Davies, 2005).

7.3 Strategies (Methods) used to overcome the challenges

The farmers reported various methods used to overcome the challenges of predation by Indian house crows on chickens, including chasing, shouting (making noise), trapping, protecting chickens through locking, and using a catapult (known as 'Manati' in Swahili). Among these, significant impacts of control strategies were observed when using chasing and the catapult (Manati).A study conducted in Singapore demonstrated that culling, along with nest destruction and resource limitation, was effective in causing a significant reduction in the crow population to 32,000 (Brook et al., 2003). Another study in Dar-es-Salaam, Tanzania, revealed that the preferred tree species for nesting were exotic trees like Mango (*Mangifera indica*) and Madras thorn (*Pithecellobium dulce*). This suggests that, if focusing on nest destruction as a control measure, more attention can be given to these specific tree species (Shimba & Jonah, 2017).Furthermore, a study in Ethiopia highlighted various challenges, including predation on chickens by animals such as vultures, mongoose, wild cats, domestic cats, dogs, and mice. These challenges affect smallholder farmers, compelling them to adopt control strategies to mitigate the impact (Selam & Kelay, 2013).

8. Conclusions

This study revealed that predation causes a significant economic loss for farmers who keep local chickens under a free-range system. Various factors, such as seasons, the age of chickens, and localities (urban or peri-urban), influenced chicken predation and, consequently, the economic losses incurred. Farmers have adopted diverse control strategies, including chasing, shouting, and stoning, as well as using catapults (Manati) to overcome these challenges. With the increasing population of Indian house crows in central Tanzania, particularly in the Dodoma region, conflicts between this invasive species and chicken farmers are expected to rise. In response, stakeholders from the conservation sector, agriculture sector, livestock industry, and other non-governmental organizations need to collaborate to control the situation and assist farmers in overcoming these challenges.The prolonged challenges are anticipated not only to affect farmers but also to have broader impacts on other sectors (health, social, business) and the ecosystem in general. Therefore, a collaborative and coordinated effort is crucial to address the multifaceted consequences of this issue.

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