

## ENHANCING COLLABORATION IN RURAL COMMUNITY ACTIVITIES TOWARD MITIGATION OF HUMAN-WILDLIFE CONFLICT

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### Abstract

Innovation Toward Village and City  
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Human-wildlife conflict (HWC) is recognized as one of the most critical threats facing rural communities globally. In Japan, for mitigating conflict with wildlife, mainly wild deer, boar, and monkeys, community-based collaborative activity is indispensable. The government provides various support projects for enhancing these activities. This study showed the contents and status of administrative support projects implemented in Koka city, a reason that is advanced in wildlife management. Using national census data and the data collected by a questionnaire survey in 2015, the statistical relationship between implementation and HWC status and geographical, agricultural, and social characteristics of rural communities. In study area, 71 communities (75.5%) experienced implementation by June 2015. These implemented projects can be classified into three tangible projects, financial support for set up and maintenance of fences and buffer zones, and four intangible projects, the lectures or training from acquisition of knowledge to building consensus and decision making among community members. The result of logistic regression analysis showed that forest edge distance most affects implementation of tangible and intangible projects. In addition, communities with a high rate of self-consuming farmers and large areas of cultivated land were likely to implement tangible projects. Comparing HWC status among implementation and non-implementation communities, significant differences were found in the number of hunters and severity of conflict with wild boar. In particular, communities that implement intangible projects were likely to suffer serious damage with wild monkeys. This study discussed the implications for enhancing community-based collaborative activities and creating a more favorable co-existence between humans and wildlife.

### Keywords

Human-wildlife conflict ; Collaboration ; Rural community ; Sustainability ; Japan

### 1. Introduction

Conflict between humans and wildlife (Human-wildlife conflict, hereinafter called "HWC") is one of the most significant threats to rural communities globally. HWC is regarded as one of the issues of natural resource management. This issue encompasses a huge diversity of situations and species, from grain-eating rodents to man-eating tigers (Pimentel et al, 2005). Direct wildlife damage is commonly cited as the main driver of conflict (Dickman, 2010).

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In Japan, wildlife species such as boar (*Sus scrofa*, hereinafter called “wild boar”), deer (*Cervus nippon*, hereinafter called “wild deer”), and monkeys (*Macaca Fuscata*, hereinafter called “wild monkeys”) have been causing severe problems in rural communities since the 1990s by feeding on crops, burrowing in farmland, destroying facilities, and causing traffic accidents with cars and trains. Particularly in mountainous areas, physical, economic, and psychological conflict exists between residents and wildlife and threatens the sustainability of food production and rural communities. The amount of damaged agriculture and forestry products reported in 2015 was approximately 14.1 billion yen, only 0.25% of Japan’s gross agricultural production. However, according to Yamabata (2017), the estimated total financial damage could amount to 30 times the damage reported. Further, one should also take into account the mental damage such as the decrease in the residents’ will to continue practicing agriculture and living in these areas.

According to the MAFF (Ministry of Agriculture, Forestry, and Fisheries), the principle of countermeasures for reducing conflicts involves the participation of residents and collaboration between communities, hunters, and the local government. This principle contributes to a cost reduction and an increase in effectiveness (MAFF, 2007). The governments provide various administrative support projects that enhance collaborative activities in rural communities for the mitigation of HWC.

The aim of this study is to provide knowledge in Japan for creating a more favorable co-existence between humans and wildlife. The specific objectives of this study are as follows:

- To inform the contents and status of administrative support projects that enhance collaborative activities in rural communities for mitigating HWC in Japan.
- To clarify the statistical relationship between implementation status and geographical, agricultural, and social characteristics of rural communities.

## 2. Study area

Koka city, which is located in the southeastern part of Shiga prefecture in western Japan, consists of 118 village-level communities and covers an area of 481.62km<sup>2</sup> (Fig. 1). The population of Koka city is 92,533, encompassing 33,900 households (2015).

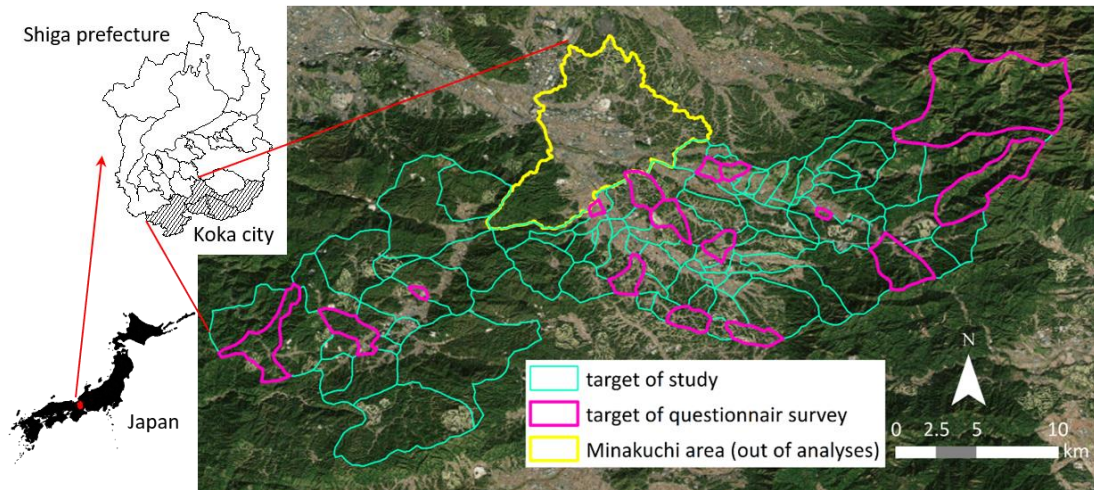


Figure 1. Location of Koka city.

Table 1. Change in the amount of agricultural damage caused by three main wildlife species in Koka city

Agricultural Damage	2007			2010			2013		
	deer	boar	monkeys	deer	boar	monkeys	deer	boar	monkeys
Damaged farm products (thousand yen)	3,810	1,907	558	85,030	36,137	9,151	25,828	13,207	13,351
Damaged farm products (t)	33.0	9.13	8.17	433.4	172.7	38.8	123.7	65.2	211.7
Damaged farmland (ha)	346.4	44.3	127.3	376.2	152.7	39.0	38.3	23.5	72.7
Ratio of damaged farmland (%)	6.5	0.8	2.4	7.1	2.9	0.7	0.7	0.4	0.2

According to the administrative plan for mitigating HWC in Koka, serious agricultural damage is caused by wild deer, wild boar, and wild monkeys. Recently, in addition to these native species, raccoons, a naturalized species, have also been found to be responsible for HWC. It is reported that the three main wildlife species caused agriculture damage to an area of 72.7ha, 211.7t, amounting to 52,386,000yen in 2013 (Table 1). The farmland where damage is reported constitutes only 1.37% of the cultivated area in Koka city. However, a lot of damage is not reported, so mitigating HWC by countermeasures is assumed to be the key administrative project of Koka city. For mitigating HWC, Koka city has established an advanced system in cooperation with Hyogo prefecture. A specialized wildlife management section has been set up, and full-time staff support the community-based actions for mitigating HWC.

This study targeted 94 agricultural communities except Minakuchi area, which is the central city area of Koka city. According to the Population and Housing Census (2015) and the Agriculture and Forestry Census (2015), there are 366 farm households in 16,900 total households, and 1,530ha of rice fields, 740ha of fields, and 1,954ha of orchards are cultivated in the study area.

### 3. Methods

#### 3.1. Data collection

To grasp the contents and the enforcement situation of administrative support projects that enhance collaborative activities in rural communities for the mitigation of HWC, official documents of local governments concerning all these projects have been used in this study.

Further, to clarify the statistical relationship between implementation status of administrative support projects and the characteristics of communities, this study employed secondary data which expressed geographical, agricultural, and social characteristics of communities and primary data which expressed the HWC status and geographical characteristics of communities (Table 2).

The secondary data was obtained from the Agriculture and Forestry Census (2015) and the Population and Housing Census (2015). While the primary data was obtained from a questionnaire survey conducted in Koka city in September 2015 and from GIS data.

Table 2. Data collection

Variables		Source	
Geographical	Type of terrain	Qualitative	Agriculture and Forestry Census (2015)
	Required time to DID	Qualitative	Agriculture and Forestry Census (2015)
	Forest edge distance (km)	Quantitative	ArcGIS Data Collection (2009)
Agricultural	Type of major crop	Qualitative	Agriculture and Forestry Census (2015)
	Rice paddy fields rate (%)	Quantitative	Agriculture and Forestry Census (2015)
	Number of farm households	Quantitative	Agriculture and Forestry Census (2015)
	Rate of population engaged in farming (%)	Quantitative	Agriculture and Forestry Census (2015)
	Full-time farmers rate (%)	Quantitative	Agriculture and Forestry Census (2015)
	Rate of self-consuming farmers (%)	Quantitative	Agriculture and Forestry Census (2015)
	Areas of cultivated land (ha)	Quantitative	Agriculture and Forestry Census (2015)
	Presence of improved field	Qualitative	Agriculture and Forestry Census (2015)
Social	Number of households	Quantitative	Population and Housing Census (2015)
	Population rate of persons over 60 years old (%)	Quantitative	Population and Housing Census (2015)
HWC status	Number of hunters	Quantitative	questionnaire survey
	Rate of victims by wildlife (%)	Quantitative	questionnaire survey
	Severity of conflict with wildlife (%)	Quantitative	questionnaire survey

The questionnaire survey was targeted at residents of all 1005 households in 19 communities, randomly selected based on the implementation status of administrative support projects. 77.9% of the questionnaires were distributed to 1903 adults, one male and one female from each household, the completed questionnaires were collected, and the data

compiled for each community was used for analysis. In addition, the forest edge distance of each communities judged from aerial photographs was calculated using ArcGIS 10.5.1.

### 3.2. Analysis

To clarify the characteristic of communities in which the administrative support projects were carried out, logistic regression analysis utilizing Backward Elimination (Wald) was conducted. The dependent variables of the analyses were presence of experience of any projects, presence of experience of tangible projects, and presence of experience of intangible projects. The independent variables were three geographical, two agricultural, and two social variables as shown in Table 2. The data of 69 communities without missing values among 94 communities were used for analyses.

Furthermore, an independent samples t-test was conducted for the purpose of confirming whether statistical differences in HWC status existed between implementing communities and non-implementing communities.

## 4. Results and Discussion

### 4.1. Contents of the administrative support projects

In Koka city, two tangible and four intangible projects (Table 3) are provided with the cooperation of Koka city and Hyogo prefecture.

The purpose of both tangible projects is financial support for the setting up and maintaining of countermeasures to mitigate HWC, but the countermeasures targeted are different. Project A supports the countermeasures that have a physical influence on wildlife by building fences around a community. Project B supports the countermeasures that have a psychological influence on wildlife by creating an open space between forest and community. If these tangible countermeasures are set up and managed appropriately, they have a significant effect on the mitigation of HWC. However, the effect of tangible countermeasures is strongly affected by how many community members acquire accurate knowledge about wildlife and countermeasures and how many community members agree and participate in the carrying out of such countermeasures.

Therefore, the local government provides three intangible projects (C, D, E), and calls for implementation of these forms of intangible support before implementation of tangible projects to communities that have suffered HWC. From the acquisition of general knowledge to making action plans, wide intangible support is prepared for. In principle, the first form of support is the intangible project, but cases of tangible projects being carried out at first are not rare. Furthermore, additional flexible financial support (Project F) is offered to communities that have already implemented any one of the tangible projects and any one of the intangible projects.

Table 3. The contents of administrative support projects for mitigating HWC in Koka city

Administrative support projects	Type	Contents
A Support for the invasion prevention fences	Tangible	Financial support toward the purchase expense of the material for permanent fences to prevent the invasion of wildlife
B Support for the buffering zone	Tangible	Financial support for creating and maintaining of an open space as a buffer zone between the community and forest area that are habitation areas of wildlife
C Class	Intangible	Provision of general information about the ecology and damage and countermeasures of wildlife
D Check of community environment	Intangible	Workshops for community members to understand damage, make decisions, and build consensus regarding countermeasures
E Training in making action plans	Intangible	Training in making action plans regarding countermeasure to develop community leaders
F Support for carrying out countermeasures	Intangible	Additional financial support for carrying out of countermeasures for communities that have already implemented any one of the tangible projects and any one of the intangible projects

Table 4. Implementation status of administrative support projects for mitigating HWC in Koka city (as of June 2015)

	Number of communities
Implementing	71 (75.5%)
A :51 / B: 20 / C: 13 / D: 37 / E: 26 / F: 20	
any tangible project: 56 / any intangible project: 50	
only tangible project: 21 / only intangible project: 15 / tangible and intangible project: 35	
Non-implementing	23 (24.5%)

#### 4.2. *Implementation status of the administrative support projects*

According to the public document published by the local government, 71 communities (75.5% of the study area) have had experience of implementation as of June 2015 (Table 4). The first administrative support projects for mitigating HWC that were implemented were Project D and E in 2007. The project implemented the most was Project A (51 communities), and the one least implemented was Project C (13 communities). It was recommended that the intangible projects should be implemented before tangible projects, but 21 communities implemented only tangible projects.

#### 4.3. *Statistical relationship between implementation status and characteristics of communities*

Table 5 is the results of 3 times of logistic regression analysis changing the standard of grouping. First, in case of grouping by experience of either tangible or intangible projects, 4 variables were selected in the best modelling as statistically significant variables, and 1 variable was included as statistically non-significant variables. Comparing odds ratio, communities with long forest edge distance were the most likely to implement projects. And communities with high rate of self-consuming farmer and communities with large cultivated land were likely to implement projects a little.

Second, as shown in the results about tangible project, while there are differences in strength of influence, the same four variables in the previous modelling were selected. It was found that communities in mountainous areas were more likely to implement tangible projects than communities in flatland areas. While statistically non-significant, communities with a high rate of full-time farmers

and communities with a low population rate of persons over 60 years old were likely to implement tangible projects.

Third, in the case of the analysis of intangible projects, only two geographical variables, required time to DID and forest edge distance, were selected in the equation. Moreover, forest edge distance was the only significance variable that affect implementation of intangible projects.

Through the performing of logistic regression analysis three times, it was found that forest edge distance most affects implementation of projects. Furthermore, it was found that projects tended to be conducted in the small household communities where large cultivated land is used for self-consuming farming in mountainous areas.

Table 5. Variables in the equation of logistic regression analyses

Variables	Either tangible or intangible project <sup>a</sup>		Tangible project <sup>b</sup>		Intangible project <sup>c</sup>	
	B	Odds ratio (95% CI)	B	Odds ratio (95% CI)	B	Odds ratio (95% CI)
Type of terrain	-	-			-	-
Flatland area			-7.64**	0.00 (0.00 to 0.00)		
Hilly area			-2.83	0.06 (0.00 to 1.34)		
mountainous area (ref)				1.00		
Required time to DID	-	-	-	-	-	-
Under 15 minutes					-0.37	0.69 (0.13 to 3.79)
15 - 30 minutes					1.07	2.92 (0.74 to 11.55)
Over 30 minutes (ref)						1.00
Forest edge distance	0.32**	1.39 (1.10 to 1.73)	0.46**	1.58 (1.17 to 2.13)	0.08*	1.08 (1.01 to 1.15)
Rice paddy fields rate	0.01	1.01 (0.97 to 1.05)	0.03	1.03 (0.98 to 1.07)	-	-
Number of farm households	-	-	-0.08	0.92 (0.85 to 1.01)	-	-
Full-time farmers rate	-	-	0.12	1.13 (0.96 to 1.33)	-	-
Rate of self-consuming farmers	0.07*	1.08 (1.01 to 1.12)	0.13*	1.14 (1.03 to 1.25)	-	-
Areas of cultivated land	0.00*	1.00 (1.00 to 1.00)	0.00*	1.00 (1.00 to 1.00)	-	-
Number of households	-0.00*	1.00 (0.99 to 1.00)	-0.00*	1.00 (0.99 to 1.00)	-	-
Population rate of persons over 60 years old	-	-	-0.16	0.85 (0.72 to 1.02)	-	-
Constant	-4.73	0.01	-2.34	0.10	-1.22	0.30

<sup>a</sup> $\chi^2=27.49$ ,  $p<0.01$ , Nagelkerke  $R^2=0.52$ , % of correct classifications=88.4. <sup>b</sup> $\chi^2=47.45$ ,  $p<0.01$ , Nagelkerke  $R^2=0.69$ , % of correct classifications=87.0. <sup>c</sup> $\chi^2=13.66$ ,  $p<0.01$ , Nagelkerke  $R^2=0.24$ , % of correct classifications=66.7.

\*\* $p<0.01$ , \*  $p<0.05$ , -: not adopted in the equation

Table 6. Mean differences in HWC status between implementing communities and non-implementing communities (Hating:  $p<0.05$ )

Variables	Project		Tangible project		Intangible project	
	non-implementing	implementing	non-implementing	implementing	non-implementing	implementing
Number of hunters	0.50 ± 0.58	2.38 ± 2.66	0.67 ± 0.52	2.64 ± 2.84	0.63 ± 1.06	3.11 ± 2.80
Rate of victims by wild deer	35.29 ± 42.24	40.03 ± 25.43	43.34 ± 42.51	36.50 ± 19.90	35.17 ± 29.42	42.24 ± 29.39
by wild boar	19.35 ± 11.92	39.47 ± 27.52	28.80 ± 25.85	37.97 ± 26.62	21.06 ± 14.75	46.89 ± 28.30
by wild monkeys	46.20 ± 36.41	53.69 ± 27.68	53.73 ± 35.54	50.95 ± 26.46	39.55 ± 29.16	62.94 ± 25.19
Severity of conflict with wild deer	2.62 ± 1.07	3.25 ± 0.50	2.87 ± 1.07	3.23 ± 0.37	2.95 ± 0.83	3.24 ± 0.56
with wild boar	2.23 ± 0.29	3.25 ± 0.57	2.44 ± 0.46	3.32 ± 0.57	2.58 ± 0.51	3.39 ± 0.57
with wild monkeys	3.09 ± 0.84	3.75 ± 0.61	3.23 ± 0.74	3.79 ± 0.63	3.24 ± 0.76	3.91 ± 0.50

Finally, using the data of the questionnaire survey about HWC in 19 communities, an independent sample t-test was conducted for comparing the HWC status of implementing and

non-implementing communities. As shown in Table 6, significant differences were founded between implementing communities and non-implementing communities regarding the number of hunters and severity of conflict with wild boar. In particular, communities that implemented intangible projects were more likely to suffer from not only wild boar but also wild monkeys than communities without intangible projects or with tangible projects. Human-monkey conflict is difficult to mitigate only through tangible countermeasures because of the high athletic capability of wild monkeys. It could be estimated that the necessity of agreement and cooperation among community members in communities suffering serious human-monkey conflict affected the results.

## 5. Conclusion

This study contributed to the understanding of the contents of support provided by the local government to communities for mitigating HWC, and the types of communities that were the beneficiaries of the administrative support projects in a part of Japan that is advanced in the practice of wildlife management. It was found that 75.5% of the study area had experienced the implementation of projects from 2007 to 2015, and that the projects that communities were able to carry out or that were demanded from communities varied depending on their geographical, agricultural, and social characteristics and HWC status.

The tangible projects tended to be implemented in communities that had a long forestry edge, large cultivated farmland in mountainous area, large numbers of self-consuming farmers, and few households. In the case of intangible projects, except for forest edge distance, no other characteristic of communities had significant effects on implementation. However, the intangible projects were more likely to be implemented in communities that had suffered from serious damage by monkeys than wild deer and wild boar. It was estimated that this result could have been influenced by the fact that consensus and collaboration among community members is indispensable to mitigate damage by wild monkeys, while the invasion of wild deer and wild boar could be prevented by physical countermeasures.

It was estimated that administrative support should be varied depending on the characteristics of communities and the habitation status of wildlife. This flexible support might raise the safety of food productions and create a more favorable co-existence between humans and wildlife.

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