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DEVELOPMENT OF THE ANALYSIS METHODS ON IMPACTS FOR RARE RAPTOR BY LARGE DAM CONSTRUCTION PROJECTS

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INTRODUCTION

Large dam construction projects to supply water and/or generate electricity are necessary for people to have a comfortable life. However, no matter how necessary those development projects are, the impacts on the environment must be considered and the projects justified in relation to environmental considerations. In Japan, Environmental Impact Assessment (EIA) is applied to large dam construction projects subject to the Environmental Impact Assessment Law enacted in 1997. Its objective is to consider mitigation measures reflecting the assessment result. The environmental factors subject to EIA are various, such as Air, Water, Flora and Fauna. Ecosystem is one of the important environmental factors in EIA.

To evaluate impacts caused by large dam construction projects to ecosystem, notable species are usually selected in terms of the upper species in food chain. In Japan, the birds of prey, especially Mountain Hawk Eagle *Spizaetus nipalensis* (Hodgson, 1836), are often selected, since such projects are often executed in their habitats and people have a great interest in *S. nipalensis* as an indicator species of natural forests. *S. nipalensis* inhabits mountainous areas throughout Japan as a resident species, and feeds on various animals such as hares, copper pheasants and snakes (Ministry of the Environment, 2002).

S. nipalensis is listed as an endangered species in The Threatened Wildlife of Japan - Red Data Book compiled by the Ministry of the Environment in 2002.

Mountain Hawk Eagle
Spizaetus nipalensis

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In order to investigate impacts caused by a dam construction project to *S. nipalensis*, firstly the potential breeding sites and hunting areas of each pair are estimated by the analysis using data of field studies, vegetation and geographical features. Then the estimated potential breeding sites and hunting areas are lapped over the project sites, and the proportions of alteration in those areas are evaluated. Finally the impacts expected to occur to the pairs of *S. nipalensis* are evaluated carefully, utilizing data from completed dams and projects under construction where *S. nipalensis* inhabits.

This paper reports on the analysis methods devised to estimate the potential breeding sites and hunting areas of *S. nipalensis*, and also the attempts of mitigation measures with concrete cases in dam construction projects.

THE BIOLOGY OF MOUNTAIN HAWK EAGLE IN JAPAN

Investigated data about *S. nipalensis*, have been collected from studies in areas planned or executed dam construction projects under the jurisdiction of the offices of Ministry of Land, Infrastructure and Transportation and Japan Water Agency from 1994 to 2005. Total 477 breeding data of 107 pairs were collected.

The interior structure of home range of *S. nipalensis*

Mountain Hawk Eagle's Biology Research Group (2000) defined the interior structure model of home range of *S. nipalensis* as follows (Fig.1).

- Core Area: the area used relatively high rate; the annual life is based on this area,
- Breeding Territory: the area protected during breeding season,
- Home Range of Fledgling: the area used by the fledgling for a while after leaving the nest.

According to this model, the interior structures of home range of *S. nipalensis* were estimated. The average area of Core Area which was not affected by any dam construction projects, was 8.6 km^2, and the average area of Breeding Territory was 3.2 km^2 (Fig.2). Both the Core Area and Breeding Territory tended to be larger when rates of forest included got smaller (Fig.3). The minimum forest area was about 4 km^2 in the Core Area and 0.7 km^2 in the Breeding Territory.

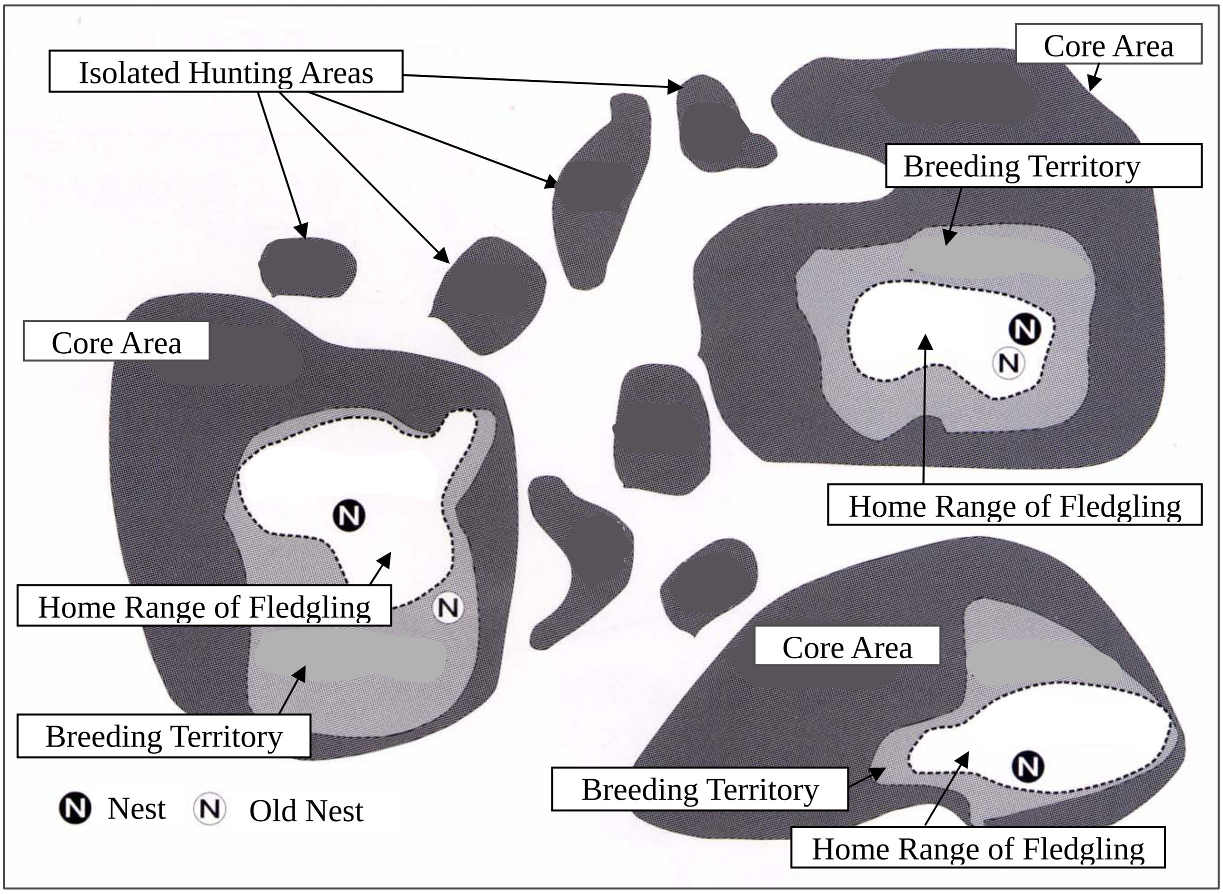


Fig. 1 Interior Structure Model of Home Range of *S. nipalensis* (WEC, 2001)

Table 1 Area of Core Area and Breeding Territory

Item	Core Area	Breeding Territory
Maximum	23.3 km^2	7.1 km^2
Minimum	3.0 km^2	0.7 km^2
Average	8.6 km^2	3.2 km^2
Standard deviation	3.8	1.7
Number of data	33	32

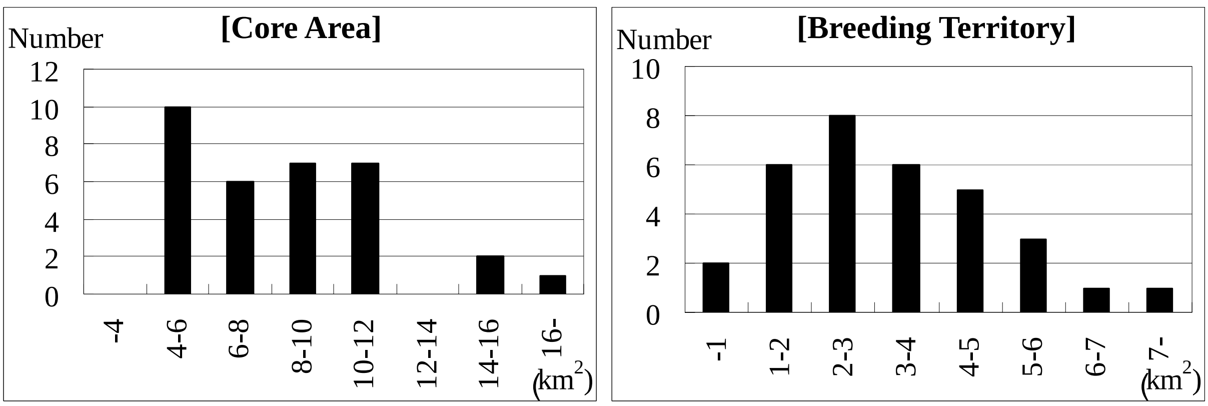


Fig. 2 Areas of Home Range of *S. nipalensis*

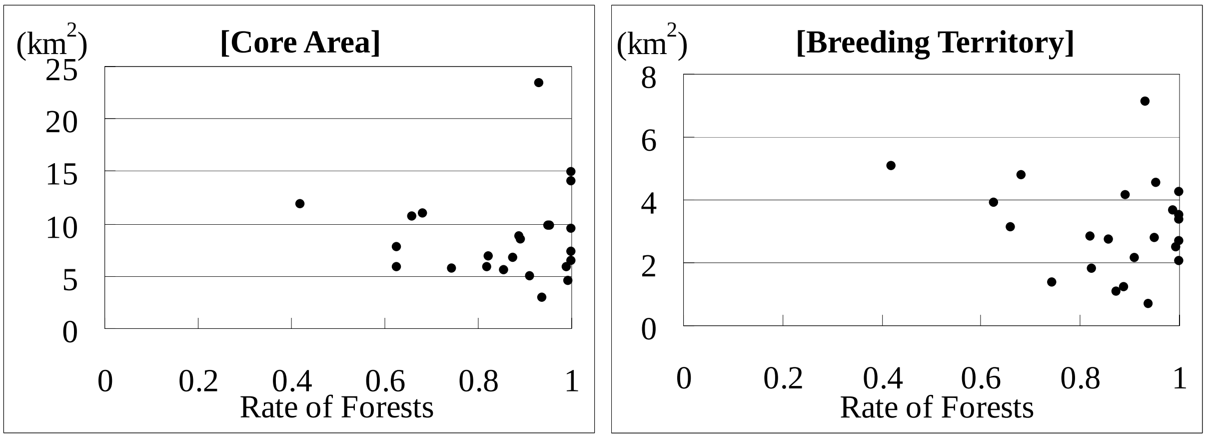


Fig. 3　Rates of Forest in Home Range of *S. nipalensis*

Environmental Conditions of Breeding Sites

Utilizing data of 62 nests from 44 pairs, the environmental conditions of nest sites were analyzed from such a point of view as vegetation, altitude, slope angle and direction, location in home range and distance from the closest nest of neighboring pairs (Table 3).

Table 3　Features of Environmental Conditions of Nest Sites

Item	Feature
Vegetation	natural deciduous broad-leaved forests, pine or fir forests
Slope angle	between 15 and 50 degrees
Slope direction	mostly south
Altitude	involved in 10 to 50 % of the highest altitude in the core area
Location in the home range	varied, not showing any relations
Distance from the closest nest of neighboring pairs	longer than 1.5km

Environmental conditions of hunting areas

The environmental conditions of hunting areas of *S. nipalensis* showed clear regional differences. Nanami *et al.* (2006) analyzed the locations of hunting behavior observed and vegetation about 37 pairs by logistic regression analysis, and reported that the environmental conditions of hunting areas were various except for the distance from the nest. Kashiwabara *et al.* (2005) studied the food animals brought into the nests with CCD cameras, and found the ratio of species of food animal varied regionally, reaching to the same conclusion, that is, *S. nipalensis* hunts in various environments according to the features of inhabit area.

Breeding

According to Mountain Hawk Eagle’s Biology Research Group (2000), the success rate of breeding of *S. nipalensis* was 37.5% in Suzuka Mountains (1987-1998), 70 to 80% in Nara

Prefecture (1983 to 1994), 85.7% (1981 to 1985), 62.5% (1986 to 1990), 36.8% (1991 to 1995), and 8.4% (1996) in mountainous regions of western Japan.

The success rate of breeding which was calculated from collected data in each breeding season when any dam construction projects were not executed, was about 36 %, and only 1/5 of pairs were succeeded in the previous year (Table 4). *S. nipalensis* sometimes takes care of the fledgling over one year, breeding every other year (Mountain Hawk Eagle's Biology Research Group, 2000), so it is possible that the differences in the success rates of breeding related to the breeding success in the previous year. This means that if one succeeds in breeding, it likely fails breeding in the next year.

Table 4 The Success Rates of Breeding Relating to Breeding Success in Previous Year

		Previous year			
		Not breeding	Failed in breeding	Succeeded in breeding	Total
Year of issue	Not breeding	11.6	6.3	16.1	34.0
	Failed in breeding	8.6	12.3	13.4	34.3
	Succeeded in breeding	11.1	14.4	6.3	31.7
	Total	31.2	33.0	35.8	100.0

Not breeding: breeding behavior was not observed
Failed in breeding: breeding behaviors were observed but a fledgling was not found
Succeeded in breeding: a fledgling was observed
Total number of data was 397.

ANALYSIS OF HABITAT

Estimation of potential breeding sites

With the results led by the analysis of environmental conditions of breeding sites, we devised a method to estimate the potential breeding sites of each pair of *S. nipalensis*. It follows the procedures shown below;

- Divide the Core Area of a pair by 50m x 50m mesh,
- Find such meshes which satisfy the following conditions,
  - containing a forest
  - the altitude included in 10 to 50 % of the highest point in the Core Area
  - the slope angle included in 15 to 50 degrees
  - more than 1.5 km apart from the closest nest of neighboring pair
- Classify the selected meshes according to vegetation type as shown below;
  - Rank A: natural forests
  - Rank B: Secondary forests
  - Rank C: Planted conifer forests
- See how the ranked meshes distribute; good breeding sites seemed to be when more than 30 meshes are gathered as a single group.

With this method, 85 % nests are found to be involved in Rank A meshes when group of Rank A meshes existed and 95 % nests in rank B when group of rank A meshes did not exist (Table 5). An example of estimation by this method is shown Fig. 4.

Table 5 Estimation of Potential Breeding Sites

	Mesh type including nests	Number of nest	Rate of nest (%)	Rate of mesh in the core area (%)
Group of rank A mesh exists (more than 30 meshes)	Rank A	26	86.7	19.8
	Rank B	4	13.3	18.8
	Rank C	0	0.0	11.1
	Not good for breeding	0	0.0	50.4
	total	30	100.0	100.0
No group of rank A mesh exists (not more than 30 meshes)	Rank A	0	0.0	0.8
	Rank B	19	95.0	29.3
	Rank C	1	5.0	16.4
	Not good for breeding	0	0.0	53.4
	Total	20	100.0	100.0

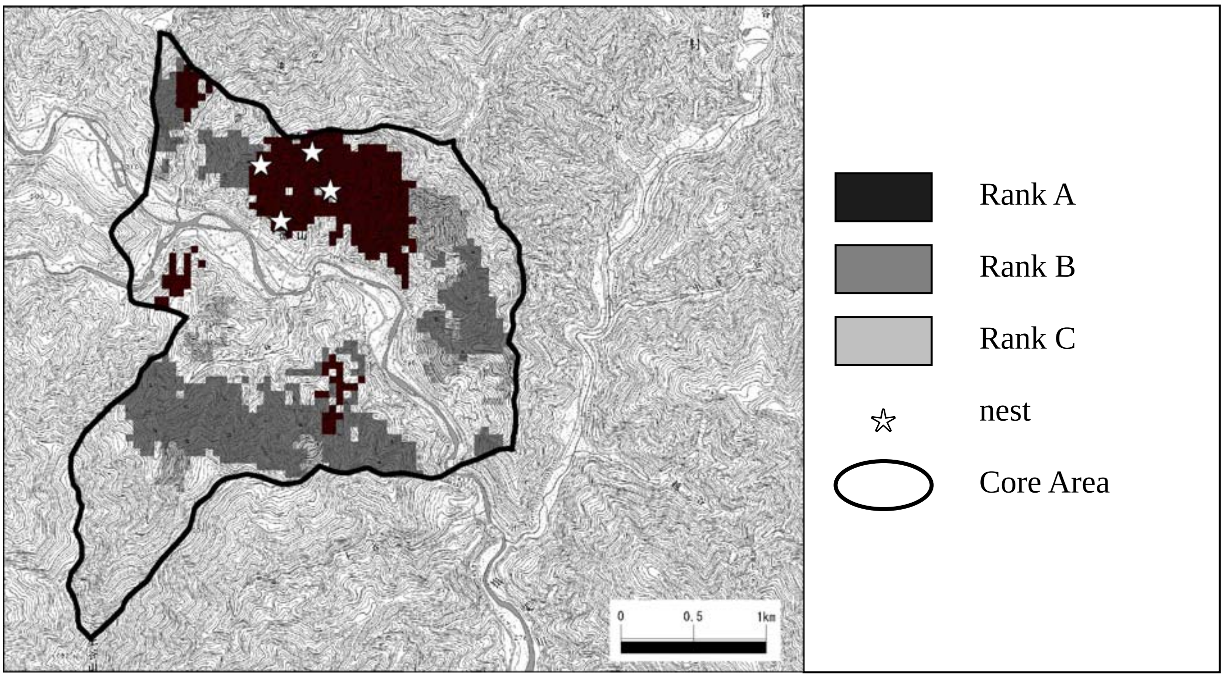


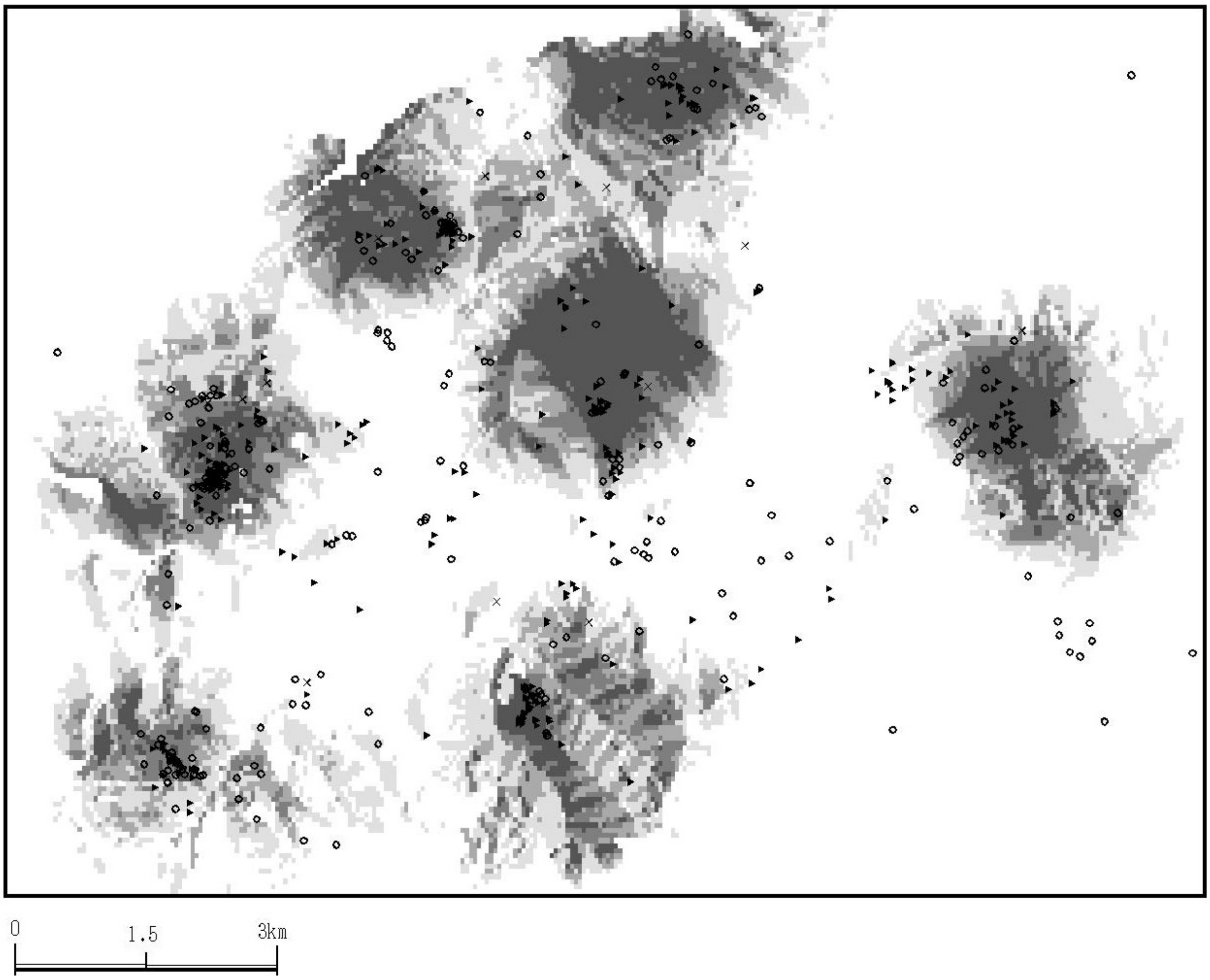
Fig. 4 Estimation of Potential Breeding Sites of *S. nipalensis*

Estimation of potential hunting areas

Since the habitat of *S. nipalensis* is mountainous, the chances to observe hunting behaviors are restricted, and also the observation areas tend to be distributed unequally. Nanami *et al.* (2006) analyzed hunting areas of *S. nipalensis* pairs by logistics regression analysis, taking hunting behaviors as response variables and environmental conditions, where hunting behaviors were observed, as explanatory variables. They devised a logistic equation to estimate suitable hunting areas that have high probability to be used in the Core Area. The estimation follows procedures shown below;

- Divide the Core Area of a pair by 50m x 50m mesh,
- Determine the response variables as whether any hunting behaviors were observed or not. Hunting behaviors include hunting, perching for seeking prey and going in or out from forests,
- Determine the explanatory variables from GIS data,
    - Slope angle,
    - Slope direction,
    - Vegetation,
    - Distance from river,
    - Distance from nest,
    - Distance from large artificial structure,
- Analyze meshes satisfying the following conditions;
    - Less than 1 km from an observation point,
    - Having land surface being observed, not only the sky,
    - Observed for longer than 1 hour.

An example of the probabilities of using area for hunting by the logistics regression analysis is shown (Fig. 5).



Probabilities of using area for hunting

- 80% or more
- 60-80%
- 40-60%
- 20-40%
- 20% or less

Observation points of hunting behaviors

- × Hunting
- ○ Perching for seeking prey
- ▲ Going in or going out from forest

Fig. 5 Distribution of Probability of using area for hunting calculated by logistic regression analysis, Nanami *et al.*(2006)

ESTIMATION OF DEGREES OF IMPACTS

The degrees of alteration expected to occur in the followings areas under dam construction projects should be evaluated for each pair of *S. nipalensis*;

- Interior Structures of Home Range,
- Potential Breeding Sites,
- Potential Hunting Areas.

By lapping the results obtained from field studies, analysis of breeding sites, hunting areas and Core Area over the project area, the degree of each alteration can be evaluated. Details of impacts followed by each alteration are estimated by referring to data obtained at established dams and projects under construction. For example, it has been reported that a pair being its Core Area occupied by reservoir with 18% had succeeded in breeding, the maximum alteration in the core area is usually stated 20% as a criterion. To consult and evaluate the degrees of those impacts expected to occur objectively, special committees are recommended to be prepared for each dam construction project.

MITIGATION MEASURES

According to estimation of degrees of impact, if the dam construction project is afraid of influence inhabitation or breeding of *S. nipalensis* pairs, mitigation measures such as following will be taken,

- alteration of project plans such as routes of road and locations of quarry,
- early reforestation at project sites.

For estimation of impacts to breeding caused during construction works, the data of location of construction sites and breeding sites should be considered. The location data includes distance between construction sites and breeding sites, visible sight from breeding sites and so on. If construction works are afraid of influence breeding of *S. nipalensis* pairs, mitigation measures such as following will be taken,

- pause of project procedures during breeding season when construction occurring near breeding sites,
- use of low noise and low vibration machines,
- use of inconspicuous colors for machineries and temporary facilities.

ABOUT FURTHER STUDIES

The methods to analyze the breeding sites and hunting areas of *S. nipalensis* have been devised. However, there are still several unknown factors about the degrees of impacts caused by dam construction projects that could influence breeding and hunting. Therefore, further studies are necessary to improve the accuracy of estimation of analysis. Beside of this, it should be noted that for preservation of *S. nipalensis*, studies on impacts should be considered for not only individuals of *S. nipalensis*, but for whole population existing around the project area.

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