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Judul Artikel: Habitat Suitability Index (HIS) of Surili (Presbytis comata Desmarest, 1822) in mixed forest of Kuningan District, West Java-Indonesia

DAFTAR ISI

DAFTAR LAMPIRAN

Judul Artikel: Habitat Suitability Index (HIS) of Surili (*Presbytis comata* Desmarest, 1822) in mixed forest of Kuningan District, West Java-Indonesia

Proses 1. Pemberitahuan bahwa Naskah sudah dikirim ke pengelola Symposium Internasional
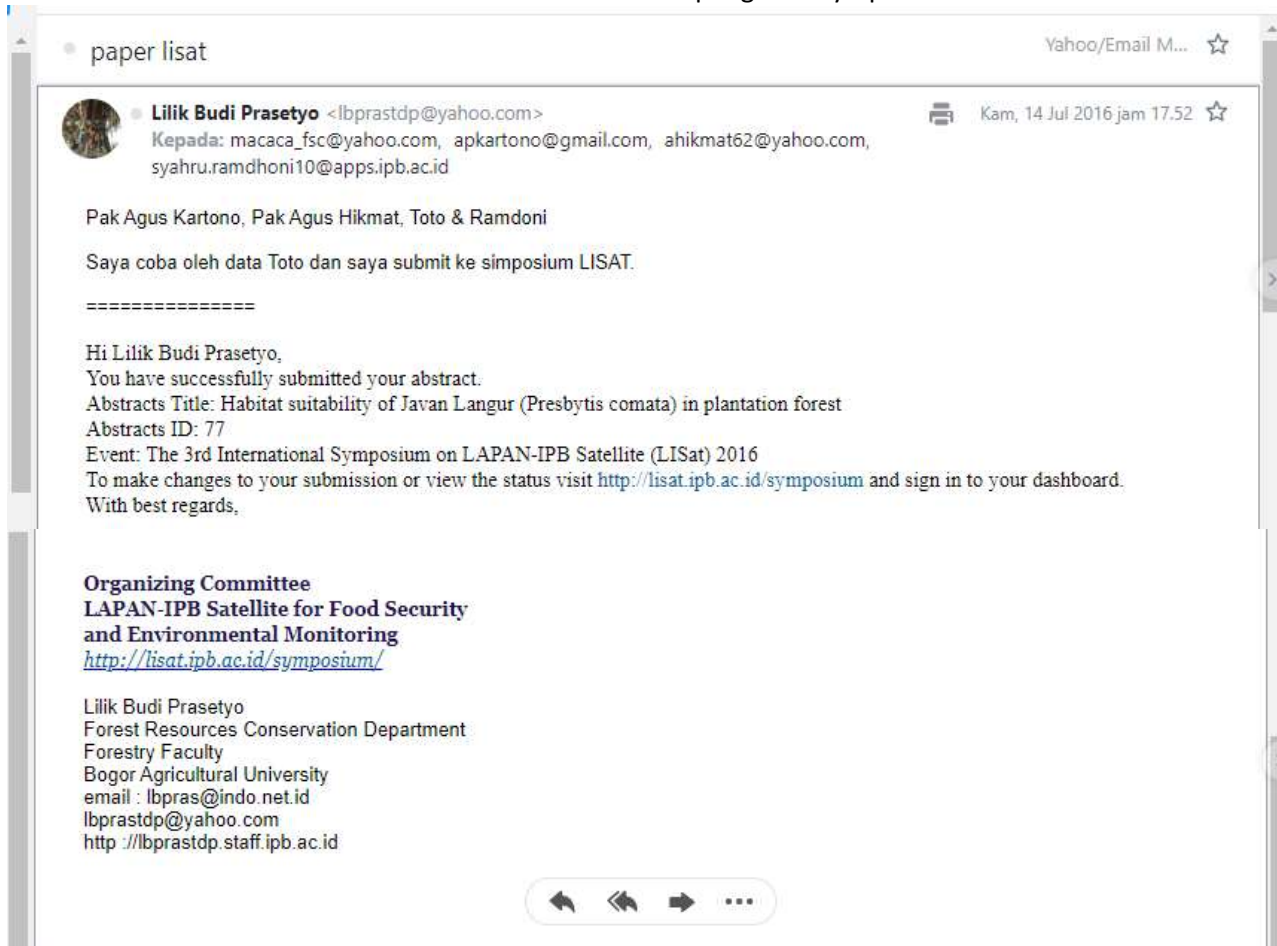
Proses 2. Pembertahuan batas waktu pengiriman abstrak

Proses 3. Permintaan untuk memperbaiki naskah hasil telaah reviewer

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Lilik Budi Prasetyo <lbprasfb@gmail.com>
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Ditunggu secepatnya, krn deadline submission.

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Syahru Ramdhoni
Graduated Student
Department of Forest Resources Conservation and Ecotourism
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Proses 4. Pengiriman naskah yang sudah diperbaiki
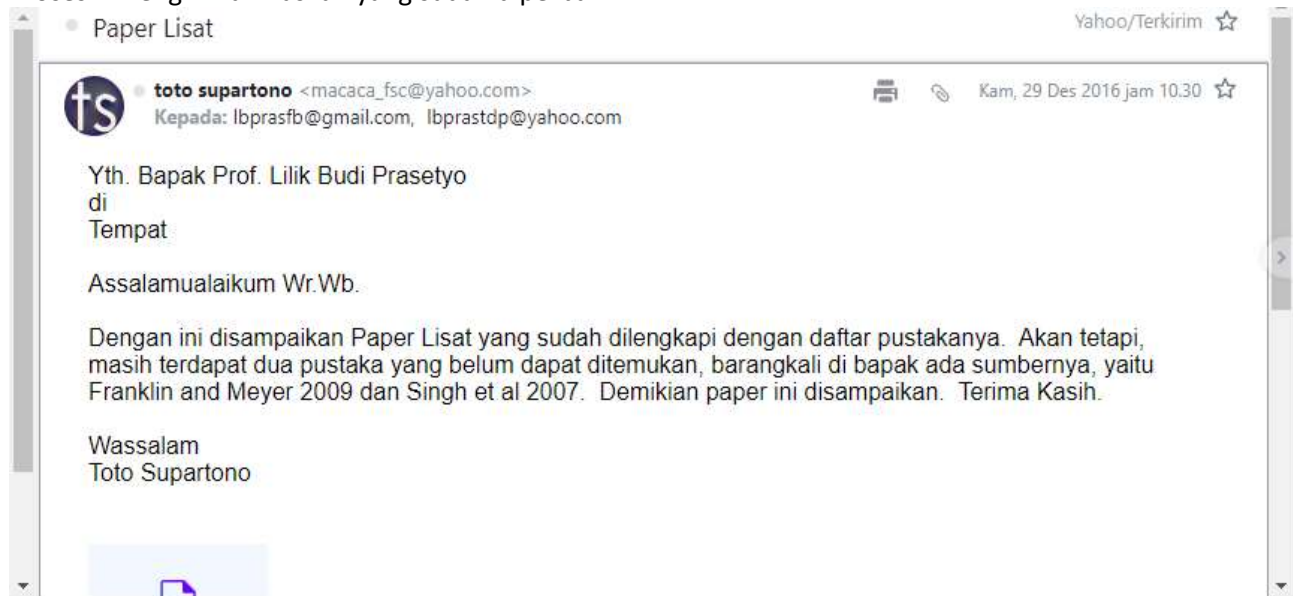
Pengiriman naskah yang sudah dilengkapi sesuai permintaan reviewer disajikan pada Lampiran 2

Proses 5. Pemberitahuan bahwa artikel sudah dipublikasikan

Naskah yang sudah dipublikasikan disajikan pada Lampiran 3

Habitat Suitability Index (HIS) of Surili (*Presbytis comata* Desmarest, 1822) in Mixed Forest of Kuningan District, West Java-Indonesia

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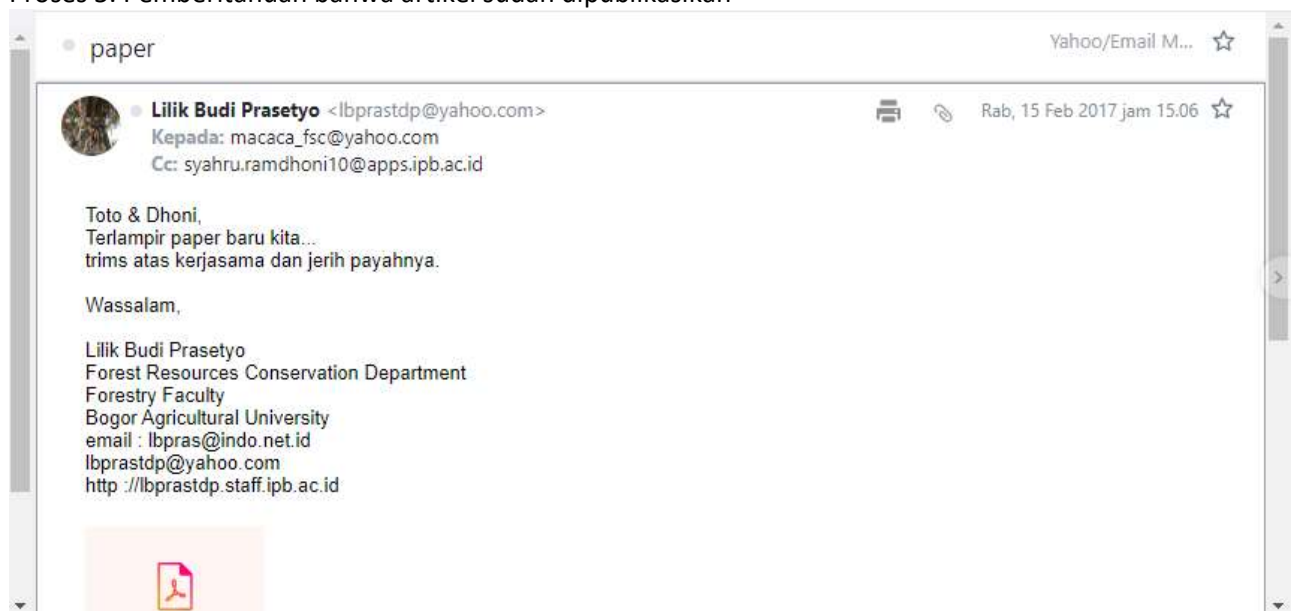
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Abstract. Java has been experiencing deforestation due to high population pressure. A lot of natural forests which play an important role as wildlife habitat are loss. The remaining natural forest distribute in mountainous areas in the form natural conservation area, meanwhile the others have been converted into settlement and infrastructure, food crops, cash crops plantation, estate and private forest plantation. Javan langur (*Presbytis comata*) is an endemic species of Java and used to utilize natural forest as their habitat. However, in a recent observation the species is found inside plantation forest in Kuningan district, West Java. This is a unique finding, due to the fact that a plantation forest is not suitable habitat for Javan langur. The research is aimed to develop Habitat Suitability for this species based on physical, biological and human disturbance factors. Data on Javan langur presence and its habitat component were derived from field observation and secondary data/map. Meanwhile analyses were conducted using GIS, and Remote sensing software, while SPSS software is used for statistical analysis.

1. Introduction

Surili is an endemic species of Java Island and found only in West Java and Central Java [1] [2]. This is one of endangered species [3] and listed in the Appendix II of CITES and protected by Indonesian government through Government Regulation No. 7/1999. Indonesian Ministry of Forestry incorporates this species into its list of conservation priority species (Ministry Regulation No.P.57/Menhut-II/2008). Based on Hoogerwerf (1970) [4], this species is mainly foraging inside natural forest. In addition, Surili was found in highland natural forest of Mount Halimun [5] [6] [7], Mount Salak (Siahaan, 2002), Mount Gede and Pangrango [2], Mount Ciremai [9] [10] [11], Nature Reserve of Mount Tukung Gede (Melish and Dirgayusa, 1996) and lowland natural forest in Ujung Kulon (Heriyanto and Iskandar, 2004). However, recent records show that surili is also found in mixed forest, which is a mixture of secondary forest, pine plantation and agroforestry adjacent to agricultural land and human settlement in Regency of Kuningan (Supartono, 2016). This discovery is very interesting to be studied in-depth because the fact of the distribution mentioned above is different from the nature of surili which is very sensitive to human disturbance as well as to feed and habitat preferences in natural forests. Perhaps this is one of adaptation strategies applied by the surili in a state of urgency, due to the existence of natural forests that are drastically reduced, degraded and fragmented. There is a necessity to investigate relationships between the existence of the species on the one hand and various variables of components of habitat that

affect the distribution of surili on the other hand, both abiotic (elevation, slope) and biotic (feed, cover) components and disturbance from human activity, so that one can predict or map levels of habitat suitability of surili in form of index on a landscape scale. This is important as a basis for conservation of species, habitat and risk management (Franklin and Meyer, 2009).

In spatial term, the determination of habitat suitability index (HSI) can be done by overlaying a variety of thematic maps, and spatial analysis can be done either in subjective or objective manners. Subjective spatial analysis can be done by simple weighting in which the amount of weight is determined based on the justification of researchers (expert judgment) or by an expert panel with Analytical Hierarchy Process approach. Objective analysis can be done by statistical analysis, especially if the relationship between the presence of this species and the habitat component is unknown yet. Information on the ecology of surili is very limited compared to the other primates species.

Among other statistical analysis are linear regression, general linear model/GLM/Logistic regression (Singh et al., 2007), and Multivariate. Recently, there is a development of an analysis with approach of Machine Learning Method including ANN, Genetic Algorithm and Maximum Entropy. The chosen technique of spatial analysis depends on the availability and types of data, both independent and dependent variable data. In cases of studies of wildlife that are always moving, in many cases one relies merely on the data of the species presence, thus it limits the choosing of methods of analysis. In addition to using Maxent, analytical technique that can be used is Principle Component Analysis/PCA. PCA is a technique to reduce and create new variable (Principle Component) based on original variables. The study aims to determine factors that influence the distribution of surili and to establish HSI models by using PCA.

2. Methodology

2.1. Study area
The study was conducted in the southern part of Kuningan Regency that bordering with Ciamis Regency, Cilacap Regency and Brebes Regency in the south (Figure 1). Land cover is dominated by pine plantations, secondary natural forests, agroforestry and agricultural fields (dry fields and paddy rice fields). The pine plantation forest and the natural forest are managed by Perhutani, while the agroforestry gardens are a form of community forests owned by local community. The community forest is planted with various species of trees either timber or fruit such as: sengon (*Paraserianthes falcataria*), mahogany (*Swietenia mahagoni*), teak (*Tectona grandis*), bitter bean (*Parkia speciosa*), and jackfruit (*Artocarpus heterophyllus*) [17]

2.2. Design of HSI prediction model
HSI prediction model is done by using an approach of Principle Component Analysis (PCA), using SPSS software. The geo-location where surili found were recorded. Independent variables (factors) that might play important roles in determining the existence of surili at the study area were extracted. The data of surili were divided into two groups. The first group is used to develop the model, while the second group is used to validate the model. There are 13 factors used in this study categorized as physical factors (elevation, slope, distance from river), biological factors (Normalized Difference Vegetation Index/NDVI, Bare soil index/BSI, tree density, density of feed trees, Basal Area/BA of feed and all trees, and distance from forest patch), and human disturbance (distance from settlement, distance from farms and distance from settlement). The value of each factor/variable for each observation was extracted using spatial analysis tool in ArcGIS software.
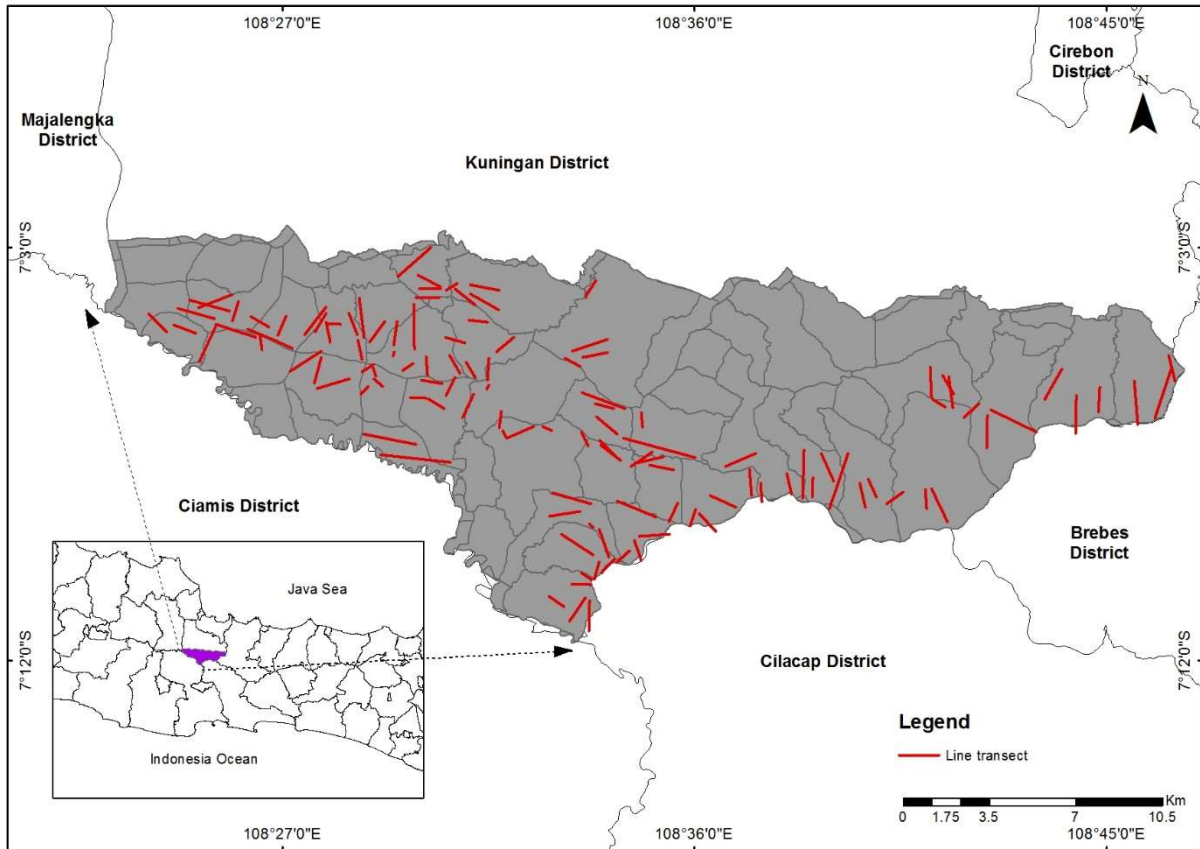
Figure 1. Study Location

PCA calculation results are considered appropriate if they meet several criteria, as presented in Table 1.

Table 1. Criteria and minimal requirement of PCA

Criteria	Minimal requirement
Ratio of observation number to variables	5 : 1 [18]
Presence of substantial correlation	Some correlation greater than 0.30 [19]
Sampling adequacy for individual variables	Acceptable if greater then 0.5 [19]
Sampling adequacy for set variables	Acceptable if greater than 0.5 [19]
Barlet test of sphericity	Less than 0.001 [19]
Communalities	Greater than 0.5 [20]
Total variance of the original variables	Between 70 – 90% [21]

PCA operation is repeated until all of the minimum requirements in Table 1 are met. After these minimum requirements are fulfilled, it will calculate number of newly formed variables (Principle component/PC) based on eigen value of bigger than 1. Total score is obtained by summing the PC multiplied by each of loading factor, with a general formula as follows:

$$\text{Score} = \sum_{i=1}^{n} (LF_i * PC_i)$$

Where :
LF_i : Loading factor of ith PC
PC_i : i^{th} PC
Afterward, result of the calculation in the form of floating number is spatialized and converted into HIS index scale of 0 - 1 by using ERDAS Imagine software.

2.3. Surili existence survey

The purpose of the survey is to obtain the information of surili and its geo-locations. Initial information of surili presence is obtained from local community members. Subsequently, the survey is designed by using line transect method (Greenwood and Robinson, 2006; Martin, 2005). The survey is started in the morning (around 6:00 am) until noon (around 12:00 pm), an investigator is walking slowly on existed paths or paths that are made available for observation (Estrada and Coates-Estrada; 1996). Total length of transect in each forest is 5-6 km and the length of each track is 0.5-3 km. Length of each tract is adjusted to the width and the vast of the area of the forest block. Placement of transect in each forest depends on the distribution of forest and cover types as well as accessibility. This arrangement is made because the forest area where the research is located has a very steep topography with a lot of ravines (Figure 2).

2.4. Physical variable (elevation and slope)

2.4.1. Elevation and slope

Elevation and slope variables are generated from Digital Elevation Model (Aster G DEM) with a spatial resolution of 30 m (http://earthexplorer.usgs.gov/) by using Erdas Imagine software (Figure 2a and 2b)

2.4.2. Distance from rivers

River data of both temporal and permanent rivers is digitized based on topographical map based on a scale of 1: 25 000. Distance of existence of surili from river is calculated spatially by using Euclidean Distance (ED) on ArcGIS software with spatial resolution of 30 meter (Figure 2c).

2.5. Biological variables

2.5.1. Tree density and tree basal area

Density and basal area of trees is calculated based on vegetational inventory using transect method (Soerianegara and Indrawan 2005). Sample plots were established at a distance of every 100 meters (Figure 2) along surili observation transect, which is placed on each type of forest cover. The size of each sample plot is 20 m x 20 m (Kusmana and Istomo 1995). Vegetation data collected includes name of tree species and tree diameter at breast height for each individual trees with diameter $\geq$ 10 cm (Onderdonk and Chapman 2000).

Considering that the surili is arboreal species (Ruhiyat 1983, Gunawan et al., 2008), data of undergrowth and trees with diameters of less than 10 cm were not collected. Information on the types of trees that have potential as food sources were obtained in sample plots by direct observation in the field and by studying results of previous studies elsewhere (Ruhiyat 1982). After data of tree density and basal area of each track is obtained, then it is converted into spatial data by using interpolation technique of Inverse Distance Weight/IDW on ArcGIS software (Figure 3a, 3b, 3c and 3d).

2.5.2. Vegetation index (normalized different vegetation index/NDVI)

NDVI indicates level of greenness of earth's surface, which has continue value from -1 up to +1. Vegetation index is calculated by using data from Landsat satellite imagery 8 OLI (row/path: 121/065), which was acquired on 11 October 2015. The higher the NDVI value indicated the faster process of photosynthesis of those areas (Figure 3e). NDVI is calculated by using the following formula:

$$NDVI = (band\ NIR-Red)/ (band\ NIR + Red)$$

2.5.3. Bare soil Indeks (BSI)

This index is calculated by using the image that is used to calculate NDVI. Contrary to NDVI, Bare soil index indicates the openness of the land, which has continues value from -1 to +1, where the higher BSI, the more open the area (**Rikimaru, 2002**)(Figure 3f) . BSI formula as follows:

$$BSI = (Band\ NIR + Band\ Red – Band\ Green)/ (Band\ NIR + Band\ Red +Band\ Green)$$

2.5.4. Distance from forest patch

Forests provide food sources, protection from disturbance and predators, and facility for movement. Thus, the distance between where the surili were recorded and the forests is considered to be a potential variable to understand the distribution of surili in the study area. Forest cover is interpreted by using satellite images of Landsat 8 OLI (path/row: 121/065), which was acquired on 11 October 2015. Landsat interpretation was done by supervised classification technique on ERDAS Imagine software (Figure 3g).

2.6. Human activity or disturbance factors

Human disturbance factor is represented by the distance from roads, residence and farms. Road data is digitized from basic/Topographic maps with a scale of 1:25 000, while the distance from farms is based on land cover maps that were constructed from Landsat satellite image data. Distance of the presence of surili is calculated spatially by Euclidean Distance technique in ArcGIS software (Figure 4a, 4b and 4c)
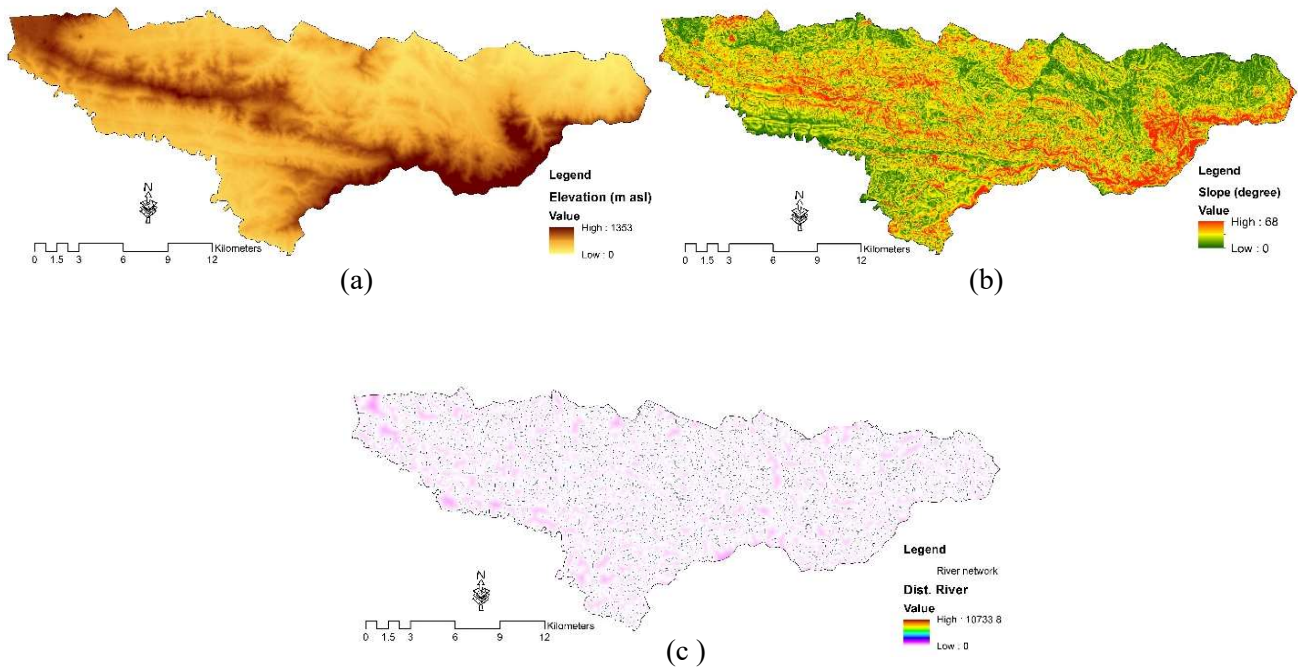

Figure 2. Physical Variables: (a) Elevation, (b) Slope, (c) Distance from river
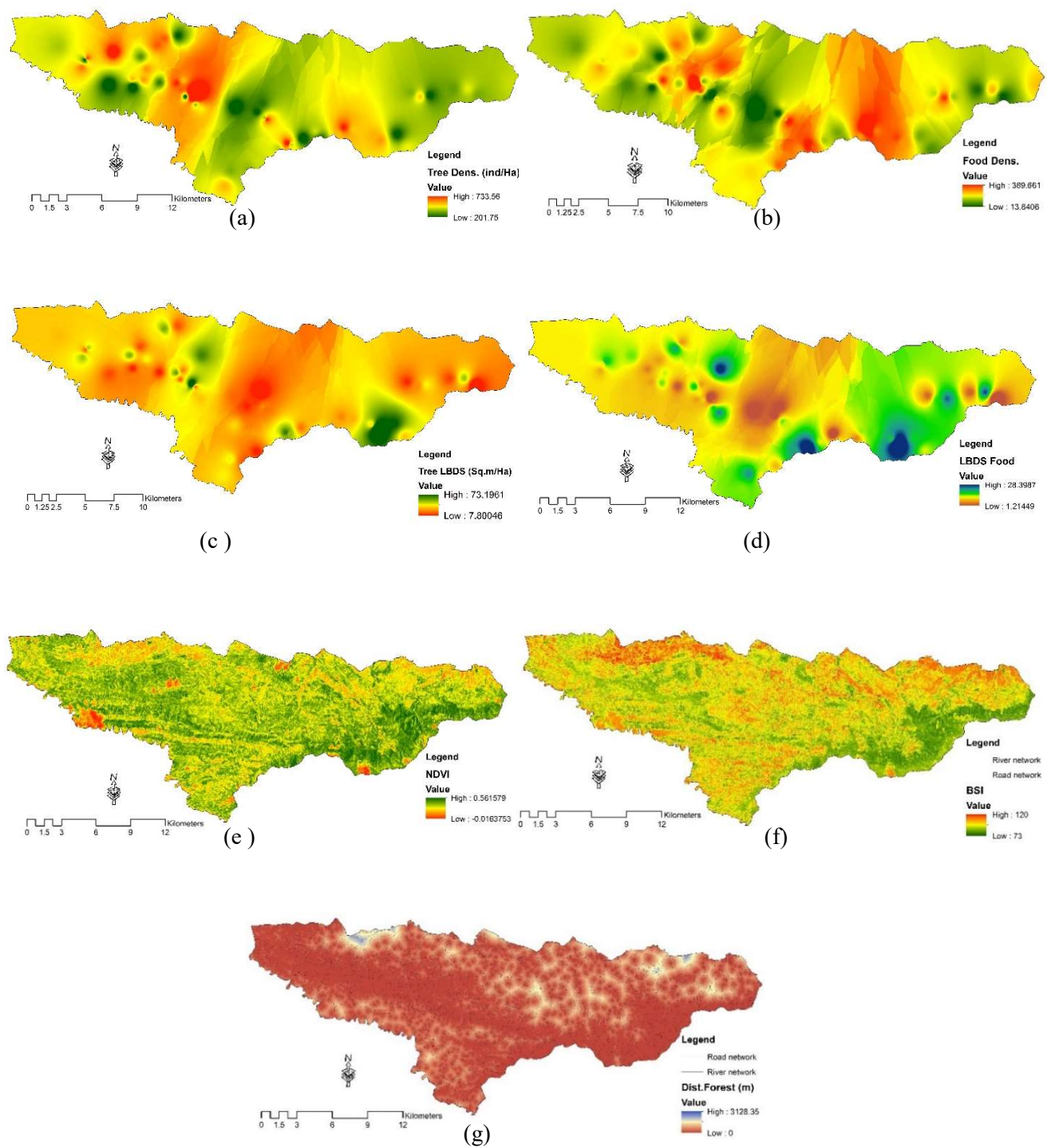
Figure 3. Biological variables: (a) Tree density (b) Feed tree density (c) Basal area of tree, (d) Basal area of feed tree, (e) NDVI, (f) BSI, (g) Distance from forest patch
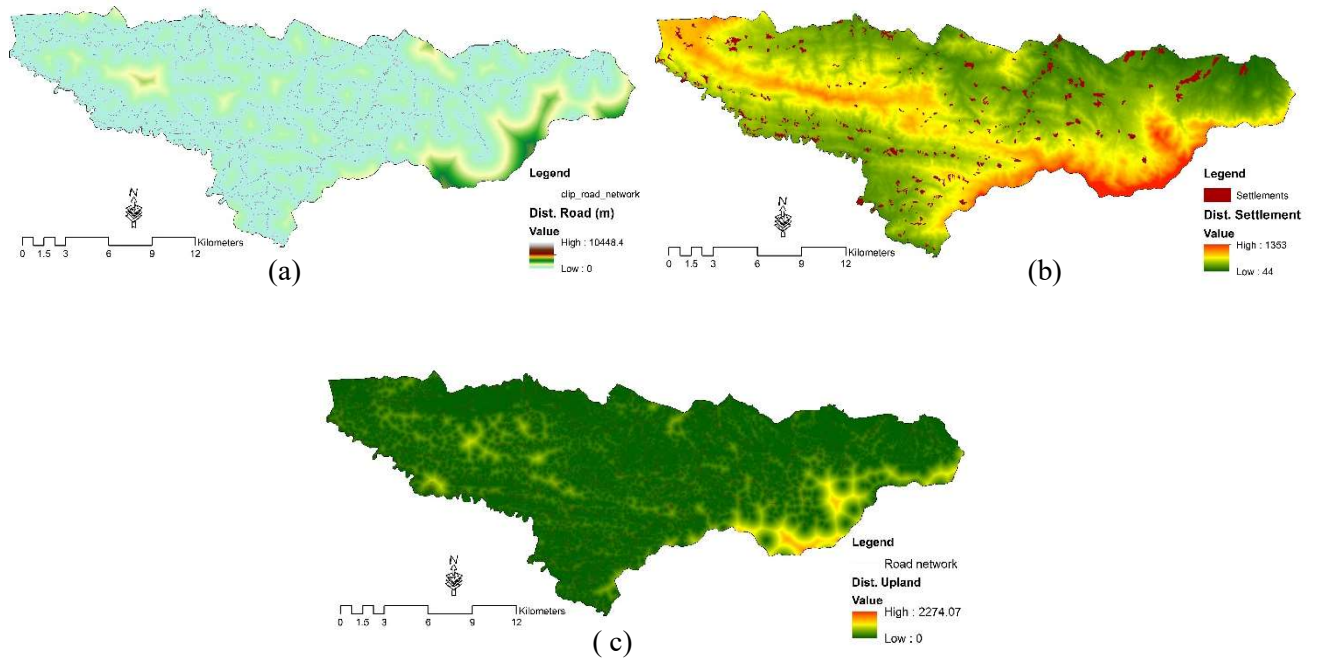
Figure 4. Disturbance Variables: (a) Distance from road, (b) Distance from settlement (c) Distance from uplands

3. Result & Discussion

3.1. Distribution of Surili

There were 156 locations of surili recorded during the survey period. When those positions are overlaid with each variable, it can be recognized the way surili responds to each of these variables. However, these correlations cannot explain properly the why surili occurred in a certain area. It is entirely possible that the existence of surili is caused by many factors which are interrelated and influencial to each other (multicollinearity). Thus, the influence of each factor can be best understood by looking at its contribution to the formation of a new variable or Principal Components/PCs.

(a) Physical Factors

Factors that are grouped into physical factors are distance from rivers, elevation and slope. The minimum distance from rivers, elevation and slope is 0 meter, 236 meters and 2 degrees, respectively. While the maximum values are 361.25 meters, 1271 meters and 48 degrees. From the distribution of data, it can be seen that the closer to rivers there is a tendency of more surili occurence. This may be due to the river condition at the study site is located in a steep valley, with good forest cover.

In connection with the elevation and slope, surili did not provide a consistent response to the increase in slope and elevation. This may be related to the fact that surili is an arboreal animal and still be able to adapt to the height range of the study sites. At a certain slope and elevation, the occurrences of surili seem to decrease (Figure 5).

(b) Biological Factors

Minimum values of bare soil Index and NDVI at the point of surili encountered were 77 and 0.155, respectively. Meanwhile maximum values were 98 and 0.47 respectively. Response of surili to Bare soil Index and Normalized vegetation index is inversely proportional. The higher the bare soil, the less of numbers of surili found, while the higher the NDVI, the more surili found (Figure 6a, b). Distance from

the nearest forest is 0 meters (in the forest) and the farthest is 573.15 meters. Distribution of the data shows that the farther from the forest the less number of points of surili presence (Figure 6g).

Minimum values of density of all kinds of trees and feed trees are, respectively, 202 and 14 individuals per hectare, while the maximum values are, respectively, 734 and 389 trees per hectare. Pattern of distribution of the data shows that the higher the density of trees, the less the point where surili presents. Conversely the higher the density of food trees, the more points of surili encountered (Figure 6c, d)

Minimum basal areas of trees and feed trees are, respectively, 7.8 square meters and 1.3 square meters. Whereas maximum values are, respectively, 73.1 square meters and 28.37 square meters. Surili's responses to the basal areas of trees and to feed trees are the same, i.e. the higher the basal area the less the point of encounter of surili (Figure 6e, f). This fact shows that the actual preference of surili towards the basal area is not linear. Probably, the preference towards the basal area decreases at a certain value.

(c) Distance from human activity

Factors related to human activity is represented by distance from roads, residential and farmland. Although surili is known as shy animal and tend to avoid humans, our observation data shows that this animal did not avoid human activities. The minimum distance of surili presence from roads, residence and farmland is, respectively, 0 meter, 30 meters and 0 meter. While the maximum distance of surili presence from roads, residential and farmland is 1776.09 meters, 3552.41 meters and 982.7 meters, respectively. From the data, there is a trend that the closer to the roads, residence and farms, the more the points of surili encounter. Many things that might explain this, and among them is the habit of local people who do not bother or expel the surili compared with that of to macaques. In addition, the roads in the research location are small roads which are located on steep slopes where canopies of trees are still interconnected. Similarly, the location of the community residence and farms are at the edge of mixed forests (Figure 7).
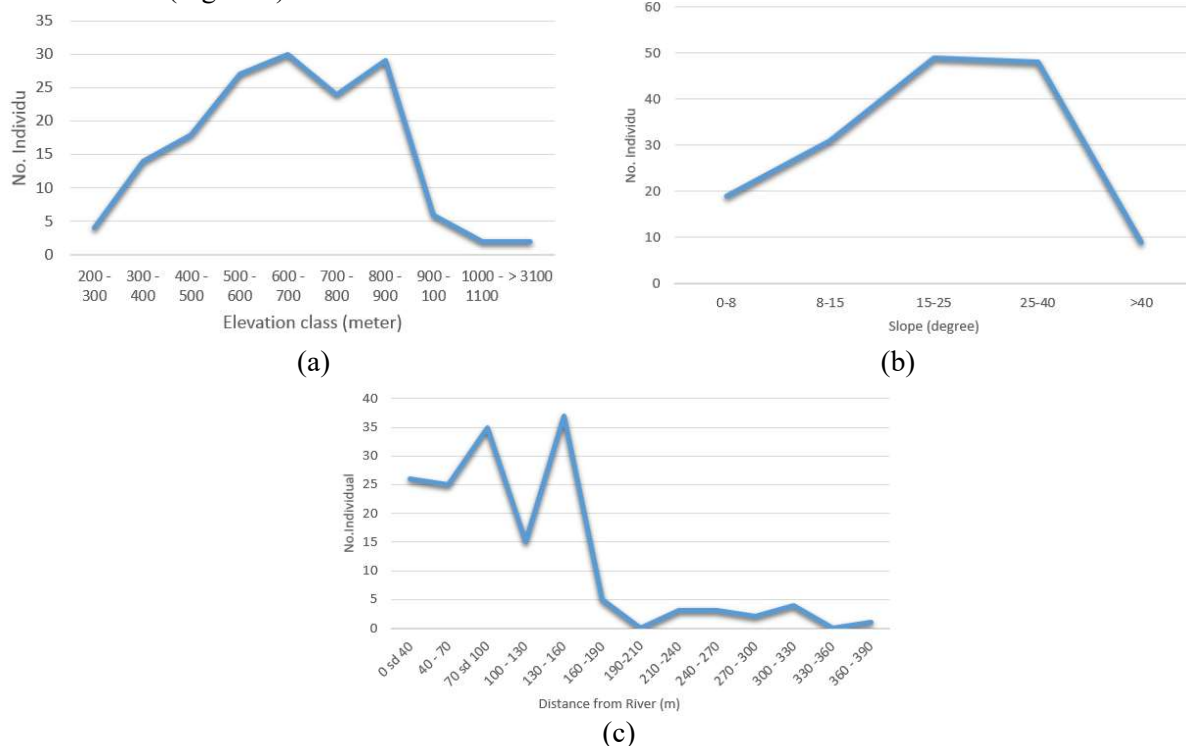

(a)

(b)

(c)

Figure 5. Number of Surili with regard to Physical variables (a) Elevation, (b) Slope and (c) Distance to River
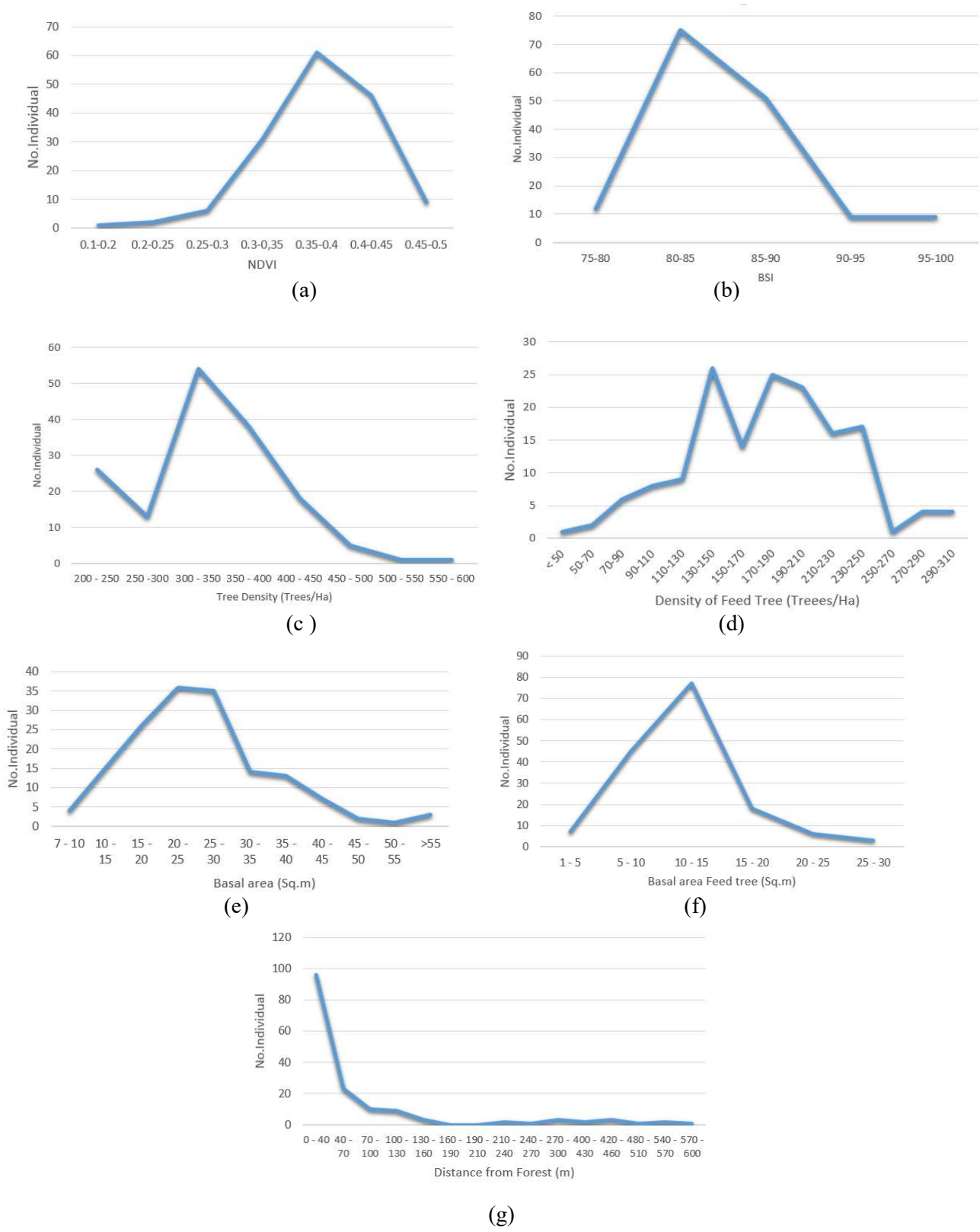
Figure 6. Number of Surili on various Biological factor variables (a) NDVI, ((b) BSI, (c) Tree density, (d) Feed tree density, (e) Basal area of trees, (f) Basal area of feed trees, (g) Distance from Forest
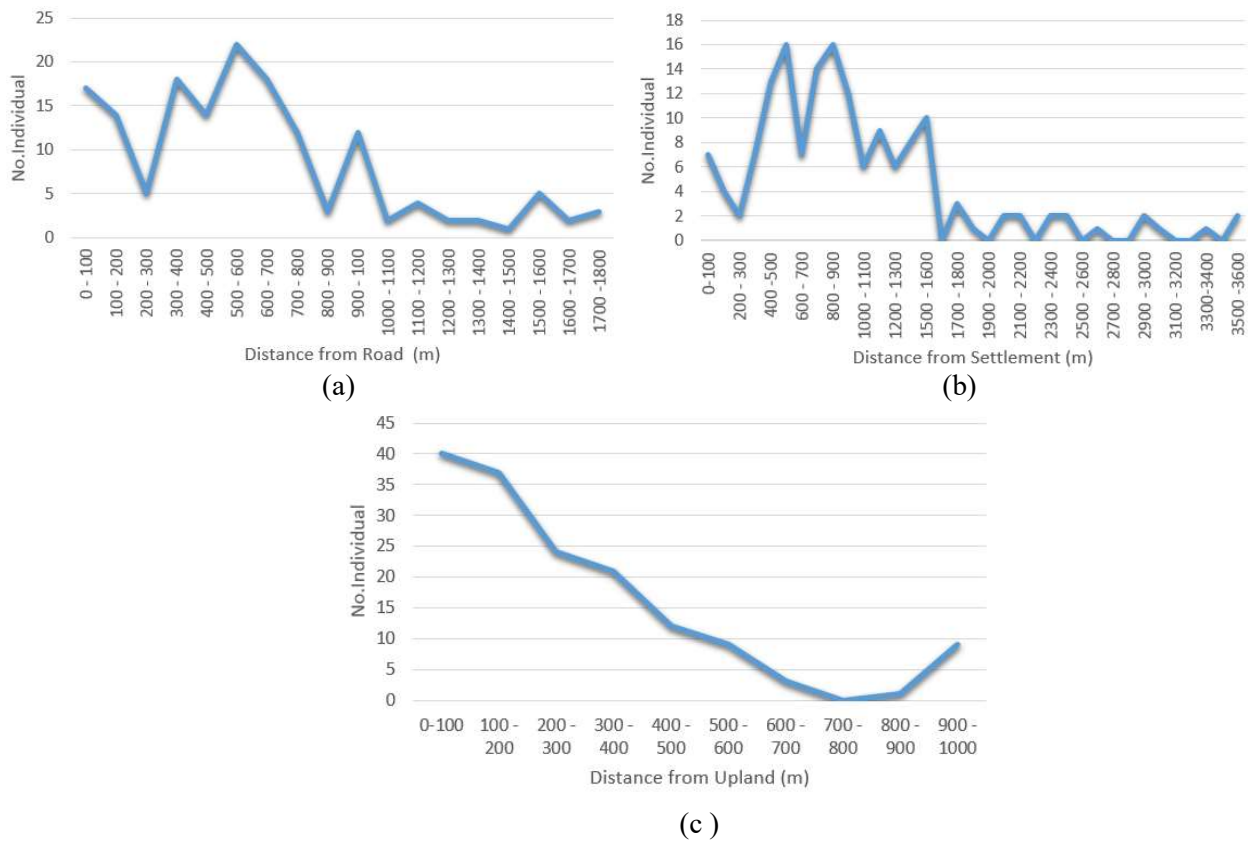
(a)

(b)

(c)

Figue 7. Number of surili on human disturbance factor (a), distance from road, (b) distance from settlement and (c) distance from farms/upland

3.2. PCA Calculation Results

A total of 152 points of surili were recorded, 98 points from this data were randomly selected to build the model, whilst 54 points used to validate the model. The random selection of the points is conducted by using ArcGIS software. Operation of PCA is performed 3 times of analysis to get an acceptable value in accordance with Table 1, so that the analysis can be continued.

Number of factors that have communalities value larger than 0.5 and having correlation greater than 0.5 are 10 factors, namely BSI, elevation, distance from roads, distance from farms, distance from forest, distance from residence, distance from rivers, NDVI, basal area of trees and basal area of feed trees. Thus, the ratio between the number of observation and the variables is 9.8 : 1. In addition, KMO value as much as 0.655 and Bartlett's test of Sphericity with a significance level of 0.00.

There were 4 PC selected, and each of them has an Eigen value of greater than 1. In cumulative PC 1, PC 2, PC 3 and PC4 contribute as much as, respectively, 33.512%, 19.677%, 14.88% and 11.367%, and the total four PCs can explain 79.44% of the data variance. PC1 through PC4 have loading factors of 3.351, 1.968, 1.489 and 1.137, respectively, (Table 2).

When we examine further it appears that each PC represents different factors. From the contribution of each factor of its original variables (Table 3), the PC 1 explains the role of human disturbance factors which positively correlated with the presence of surili, that is the farther from the road and settlement the more suitable the habitat for the surili. This new variables explain that surili is still very sensitive to human activities. This fact is in contrast to when we see only partial human disturbance factors in the above description.

Table 2. Variance contribution

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3.351	33.512	33.512
2	1.968	19.677	53.189
3	1.489	14.888	68.077
4	1.137	11.367	79.444
5	.798	7.982	87.426
6	.369	3.694	91.119
7	.293	2.928	94.047
8	.271	2.710	96.757
9	.195	1.949	98.706
10	.129	1.294	100.000

Table 3. Rotated Component Matrix

Variable	Component			
	1	2	3	4
BSI	-.231	-.860	-.206	-.066
NDVI	.166	.908	-.004	.109
Distand from road	.887	.166	.049	.175
Dist_settlmtn	.919	.119	-.181	-.034
Distance from upland	.566	.402	.470	.261
Elevation	.069	.208	.830	.178
Distance from Forest	.254	-.381	-.735	.164
Dist_river	.008	-.363	.623	-.049
Lbds_Trees	.054	.112	.066	.897
Lbds_Food	.115	.039	-.029	.906

On the PC 2 there are two original influential variables namely the BSI which is correlated negatively, and the NDVI factor which is positively correlated. This means that the lower the Bare Soil Index and the higher the NDVI, the more suitable the habitat for surili. Both of these factors are consistent with the initial analysis.

On the PC 3, factors that have high contribution are elevation, distance from rivers and forest. The distance from rivers and the elevation appear to be more in explaining that a place that is relatively far from human activities are more suitable. Likewise, the distance from the forest which negatively correlated, suggesting the role of forests as protection. The farther a spot from forest, the more unsuitable it is for habitat of surili.

PC 4 reflects the need of surili on feed and cover which is represented by the values of basal area of feed trees and basal area of all species of trees (Table 3).

3.3. Habitat Suitability Index and Its Accuracy

Result of HSI calculations indicates that the location is dominated by areas with low HSI, which are located in areas that are relatively lower area relatively flat which dominated by upland agriculture with

high disturbance from road and settlement. While high HSI are located at locations with high elevation and slope, good forest cover, and relatively far from residence, roads and upland agriculture/farms (Figure 8). The location is spatially fragmented, thus maintaining forest connectivity between those locations becomes very important.
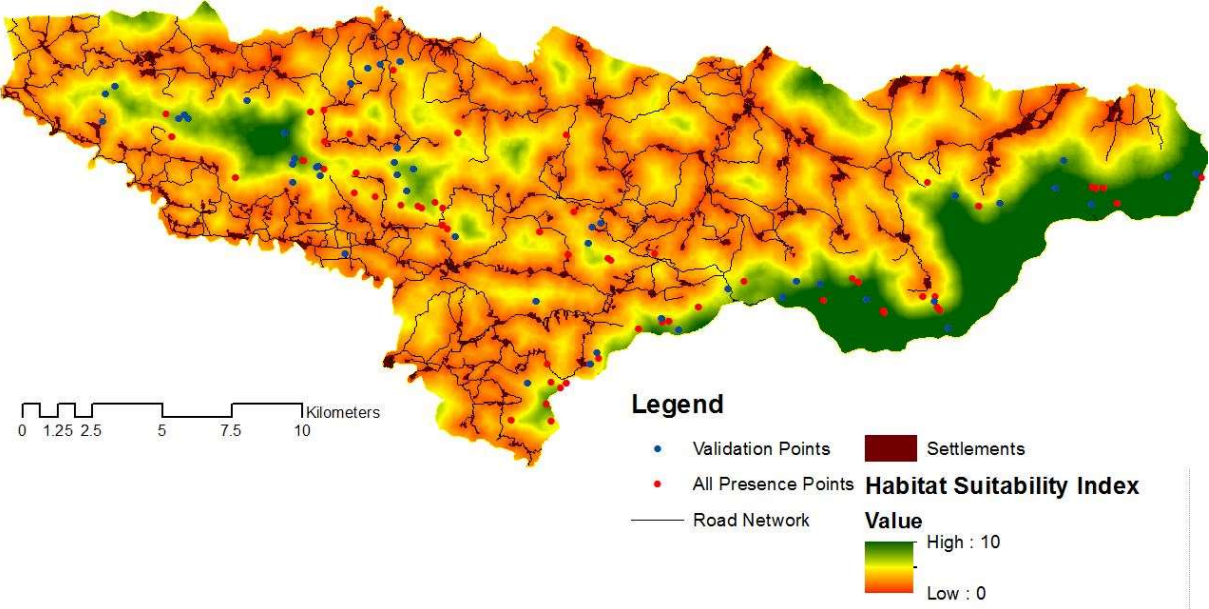

Figure 8. HSI of surili

If the HSI is divided into 5 classes, then most of the area study is unsuitable and poorly suitable, meanwhile, only small suitable area situated in forest area on hilly area (Figure 9 and Table 4). The overlay between point for validation (54 points) showed that 18 points (33.33 %) located on not suitable, 28 points (51.85 %) on Poorly suitable area, 7 points (12.96%) located on Moderately suitable and 1.85 % on suitable areas.
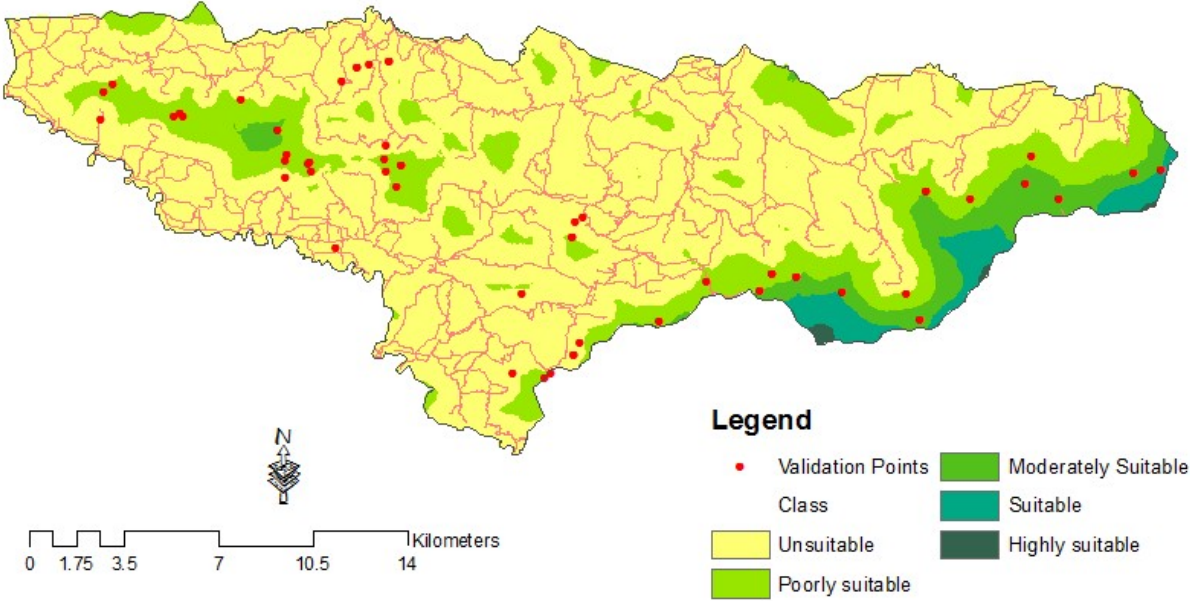

Figure 9. Suitability habitat class of surili

Table 4. Suitability class of surili

Class	Area (Ha)	Percentage (%)
Unsuitable	27,292.84	75.05
Poorly suitable	6,075.19	16.71
Moderately Suitable	1,926.53	5.30
Suitable	996.63	2.74
Highly suitable	73.61	0.20
Total	36,364.81	100.00

4. Conclusion

Surili occurrence is influenced by disturbance factor (distance from road, settlement and upland), followed by biological factor (BSI & NDVI), Physical factors (elevation, forest and distance from river) and cover and feed. The HSI could be developed based on 4 PC and showed that the study area mostly is occupied by low HIS Index or not suitable area for surili.

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Habitat Suitability Index (HIS) of Surili (*Presbytis comata* Desmarest, 1822) in Mixed Forest of Kuningan District, West Java-Indonesia

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Abstract. Java has been experiencing deforestation due to high population pressure. A lot of natural forests which play an important role as wildlife habitat are loss. The remaining natural forest distribute in mountainous areas in the form natural conservation area, meanwhile the others have been converted into settlement andinfrastructure, food crops, cash crops plantation, estate and private forest plantation. Javan langur (*Presbytiscomata*) is an endemic species of Java and used to utilize natural forest as their habitat. However, in a recent observation the species isfound inside plantation forest in Kuningan district, West Java. This is a unique finding, due to the fact that a plantation forest is not suitable habitat for Javan langur. The research is aimed to develop Habitat Suitability for this species based on physical, biological and human disturbance factors. Data on Javan langur presence and its habitat component were derived from field observation and secondary data/map. Meanwhile analyses were conducted using GIS, and Remote sensing software, while SPSS software is used for statistical analysis.

1. Introduction

Surili is an endemic species of Java Island and found only in West Java and Central Java[1] [2]. This is one of endangered species [3]and listed in the Appendix II of CITES and protected by Indonesian government through Government Regulation No. 7/1999. Indonesian Ministry of Forestry incorporates this species into itslist of conservation priority species (Ministry Regulation No.P.57/Menhut-II/2008).Based on Hoogerwerf (1970) [4], this species is mainly foraging insidenatural forest. In addition,Suriliwas found in highland natural forest of Mount Halimun [5] [6] [7], Mount Salak [8], Mount Gedeand Pangrango [2], Mount Ciremai[9] [10][11], Nature Reserve of Mount Tukung Gede [12] and lowland natural forest in Ujung Kulon [13]. However, recent records show that suriliis also found in mixed forest, which is a mixture of secondary forest, pine plantation and agroforestry adjacent to agricultural land and human settlement in Regency of Kuningan [14]. This discovery is very interesting to be studied in-depth because the fact of the distribution mentioned aboveis different from the nature of suriliwhich is very sensitive to human disturbance as well asto feedand habitat preferences in natural forests. Perhaps this is one of adaptation strategies applied by the surili in a state of urgency, due to the existence of natural forests that are drastically reduced, degraded and fragmented. There is a necessity to investigaterelationshipsbetween the existence of the species on the one hand and various variables of components of habitat that affect the distribution of surili on the

other hand, both abiotic (elevation, slope) and biotic (feed, cover) components and disturbance from human activity, so that one can predict or map levelsof habitat suitability of surili in form of index on a landscape scale. This is important as a basis for conservation of species, habitat and risk management (Franklin and Meyer, 2009).

In spatial term, thedetermination of habitat suitability index (HSI) can be done by overlaying a variety of thematic maps, and spatial analysis can be done either in subjective or objective manners. Subjective spatial analysis can be done by simple weighting in which the amount of weight is determined based on the justification of researchers (expert judgment) or by an expert panel with Analytical Hierarchy Process approach.Objective analysis can be done by statistical analysis, especially if the relationship between the presence of this species andthe habitat component is unknown yet. Information on the ecology of suriliis very limited compared to the other primates species.

Among other statistical analysis are linear regression, general linear model/GLM/Logistic regression (Singh et al., 2007), and Multivariate. Recently, there is a developmentof an analysiswith approach of Machine Learning Method including ANN, Genetic Algorithm and Maximum Entropy. The chosentechnique of spatial analysis depends on the availability and types of data, both independent and dependent variable data.In cases of studies of wildlife that are always moving, in many cases one reliesmerely on the data of the species presence, thus it limits the choosing of methods of analysis. In addition to using Maxent, analytical technique that can be used isPrinciple Component Analysis/PCA. PCA is a technique to reduce and create new variable (Principle Component) based on original variables. The study aims to determine factors that influence the distribution of surili and to establishHSI models by using PCA.

2. Methodology

2.1. Study area
The study was conducted in the southern part of KuninganRegencythat bordering with CiamisRegency, CilacapRegency and BrebesRegency in the south (Figure 1). Land cover is dominated by pine plantations, secondary natural forests, agroforestry and agricultural fields (dry fields and paddy rice fields). The pine plantation forest and the natural forest are managed by Perhutani, while the agroforestry gardens are a form of community forests owned by local community. The community forest is planted with various species of trees either timber or fruit such as: sengon (*Paraserianthesfalcataria*), mahogany (*Swieteniamahagoni*), teak (*Tectonagrandis*), bitter bean (*Parkiaspeciosa*), and jackfruit (*Artocarpusheterophyllus*) [17]

2.2. Design of HSI prediction model
HSI prediction model is done by using an approach of Principle Component Analysis (PCA), using SPSS software. The geo-location where surilifound were recorded. Independent variables (factors) thatmight play important roles in determining the existence of surili at the study area were extracted. The data of suriliwere divided into two groups. The first group is used to develop the model, while the second group is used to validate the model.There are 13 factors used in this study categorized as physical factors (elevation, slope, distance from river), biological factors (Normalized Difference Vegetation Index/NDVI, Bare soil index/BSI, tree density, density of feed trees, Basal Area/BA of feed and all trees, and distance from forest patch), and human disturbance (distance from settlement, distance from farms and distance from settlement). The value of each factor/variable for each observation was extracted using spatial analysis tool in ArcGIS software.
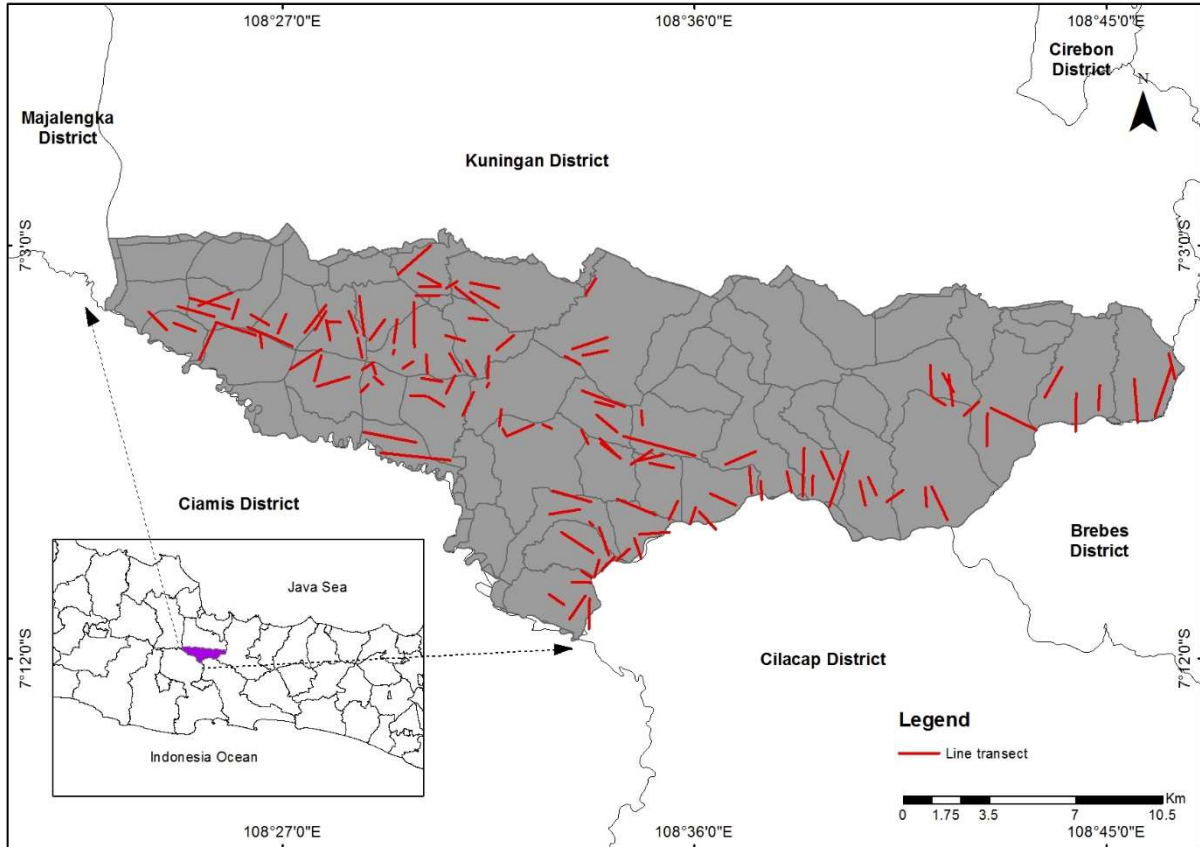
Figure 1. Study Location

PCA calculation results are considered appropriate if they meet several criteria, as presented in Table 1.

Table 1. Criteria and minimal requirement of PCA

Criteria	Minimal requirement
Ratio of observation number to variables	5 : 1[18]
Presence of substantial correlation	Some correlation greater than 0.30[19]
Sampling adequacy for individual variables	Acceptable if greater then 0.5[19]
Sampling adequacy for set variables	Acceptable if greater than 0.5[19]
Barlet test of sphericity	Less than 0.001[19]
Communalities	Greater than 0.5[20]
Total variance of the original variables	Between 70 – 90% [21]

PCA operation is repeated until all of the minimum requirements in Table 1 are met. After these minimum requirements arefulfilled, it will calculate number of newly formed variables (Principle component/PC) based on eigen value of bigger than 1. Total score is obtained by summing the PC multiplied by each of loading factor, with a general formula as follows:

$$\text{Score} = \sum_{i=1}^{n} (LF_i * PC_i)$$

Where :
LF_i: Loading factor of i^{th}PC
PC_i : i^{th} PC

Afterward, result of the calculation in the form of floating number is spatialized and converted into HIS index scale of 0-1by using ERDAS Imagine software.

2.3. Surili existence survey

The purpose of the survey is to obtain the informationof suriliand its geo-locations. Initial information of surili presence is obtained from local community members. Subsequently, the survey is designed by using line transect method [22] [23]. The survey is started in the morning (around 6:00 am) until noon (around 12:00 pm), an investigator is walking slowly on existed paths or paths that are made available for observation [24]. Total length of transect in each forest is 5-6 km and the length of each track is 0.5-3 km. Length of each tractis adjusted to the width and the vast of the area of the forest block. Placement of transect in each forest depends on the distribution of forest and cover types as well as accessibility. This arrangement is made because the forest areawhere the research is located has a very steep topography with a lot of ravines (Figure 2).

2.4. Physical variable (elevation and slope)

2.4.1. Elevation and slope

Elevation and slope variables are generated from Digital Elevation Model (Aster G DEM) with a spatial resolution of 30 m (http://earthexplorer.usgs.gov/) by using Erdas Imagine software (Figure 2a and 2b)

2.4.2. Distance from rivers

River data of both temporal and permanent rivers is digitized based on topographical map based on a scale of 1: 25 000. Distance of existence of surilifrom riveris calculated spatially by using Euclidean Distance (ED) on ArcGIS software with spatial resolution of 30 meter (Figure 2c).

2.5. Biological variables

2.5.1. Tree density and tree basal area

Density and basal area of trees is calculated based on vegetational inventory using transect method [25]. Sample plots were established at a distance of every 100 meters (Figure 2) along surili observation transect, which is placed on each type of forest cover. The size of each sample plot is 20m x 20m [26]. Vegetation data collected includes name of tree species and tree diameter at breast height for each individual trees with diameter $\geq$ 10 cm [27].

Considering that the suriliis arboreal species [28] [29], data of undergrowth and trees with diameters of less than 10 cm were not collected. Information on the types of trees that have potential as food sources were obtained in sample plots by direct observation in the field and by studyingresults of previous studies elsewhere [28].After data of tree density and basal area of each track is obtained, then it is converted into spatial data by using interpolation technique of Inverse Distance Weight/IDW on ArcGIS software (Figure 3a, 3b, 3c and 3d).

2.5.2. Vegetation index (normalized different vegetation index/NDVI)

NDVI indicates level of greenness of earth's surface, which has continue value from -1 upto +1. Vegetation index is calculated by using data from Landsat satellite imagery 8 OLI (row/path: 121/065), which was acquired on 11 October 2015. The higher the NDVI value indicatedthe faster process of photosynthesis of those areas (Figure 3e). NDVI is calculated by using the following formula:

$$NDVI = (band\ NIR\text{-}Red)/ (band\ NIR + Red)$$

2.5.3. Bare soil Indeks (BSI)

This index is calculated by using the image that is used to calculate NDVI. Contrary to NDVI, Bare soil index indicates the openness of the land, which has continues value from -1 to +1, where thehigher BSI, the more open thearea (**Rikimaru, 2002**)(Figure 3f) . BSI formula as follows:

BSI = (Band NIR + Band Red –Band Green)/ (Band NIR + Band Red +Band Green)

2.5.4. Distance from forest patch

Forests provide foodsources, protectionfrom disturbance and predators, and facility for movement. Thus, the distance between where the suriliwere recorded and the forests is considered to be a potential variable to understand the distribution of surili in the study area. Forest cover is interpreted by using satellite images of Landsat 8 OLI (path/row: 121/065), which was acquired on 11 October 2015. Landsat interpretation was done by supervised classification technique on ERDAS Imagine software (Figure 3g).

2.6. Human activity or disturbance factors

Human disturbance factor is represented by the distance from roads, residence and farms. Road data is digitized from basic/Topographic maps with a scale of 1:25 000, while the distance from farms is based on land cover maps that were constructed from Landsat satellite image data. Distance of the presence of suriliis calculated spatially by Euclidean Distance technique in ArcGIS software (Figure 4a,4b and 4c)
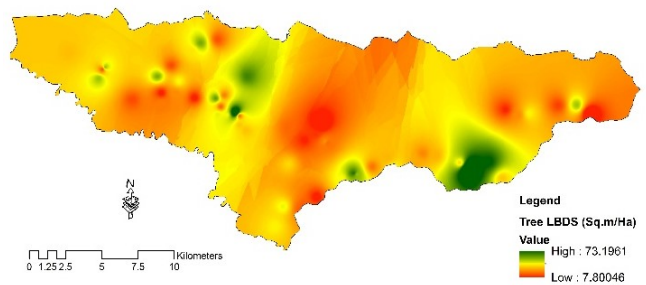

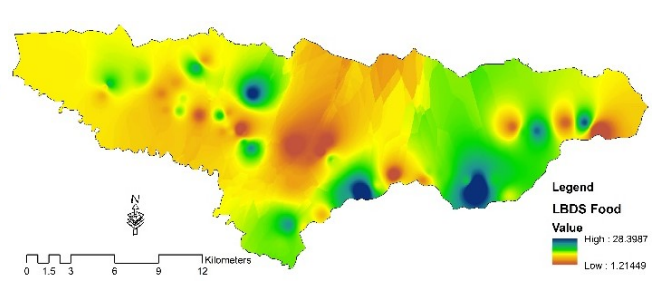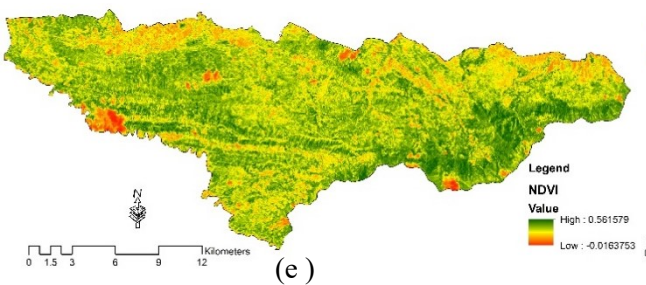**Figure 2.** Physical Variables: (a) Elevation, (b) Slope, (c) Distance from river
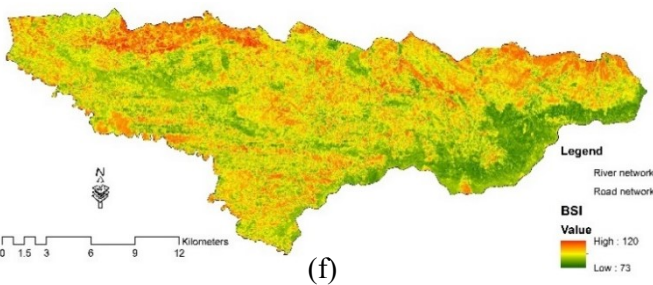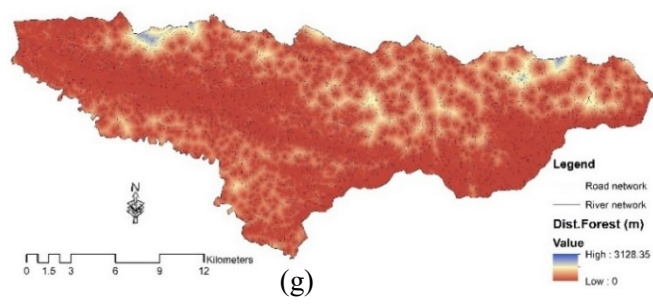
(a)

(b)

(c)

(d)

(e)

(f)

(g)

Figure 3. Biological variables: (a) Tree density (b) Feed tree density (c) Basal area of tree, (d) Basal area of feed tree, (e) NDVI, (f) BSI, (g) Distance from forest patch
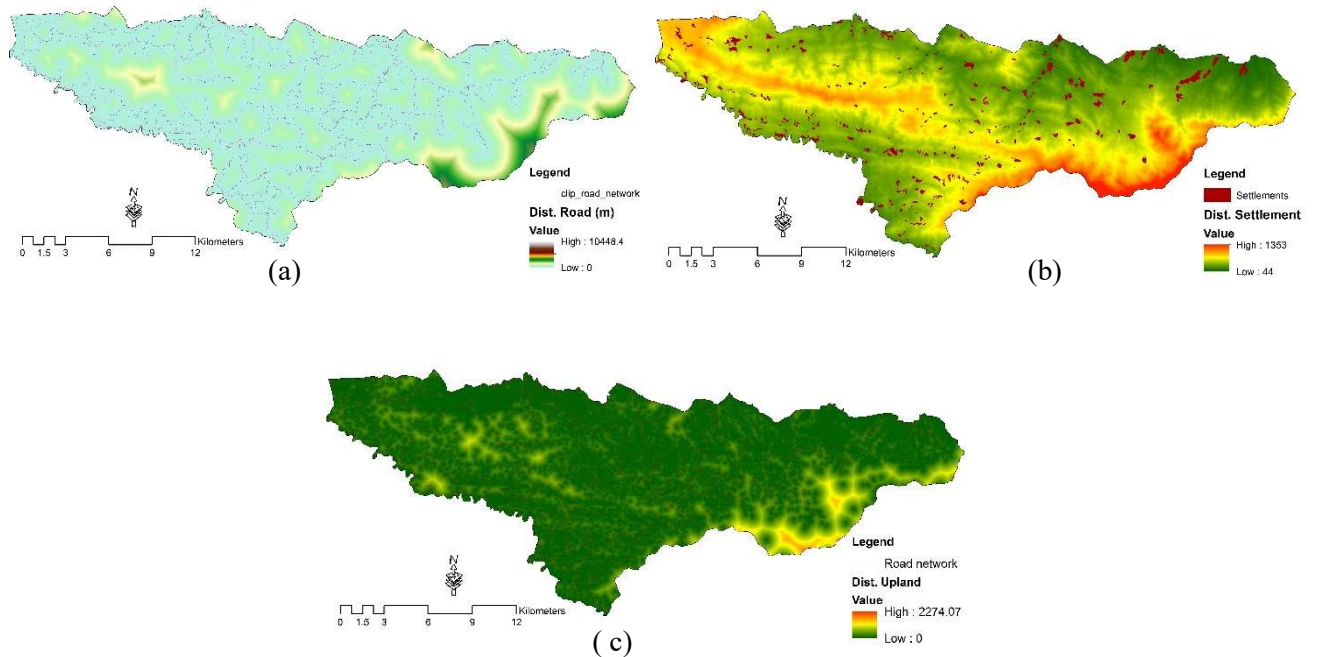

(a)

(b)

(c)

Figure 4. Disturbance Variables: (a) Distance from road, (b) Distance from settlement (c) Distance from uplands

3. Result &Discussion

3.1. Distribution of Surili

There were 156 locations of surili recorded during the survey period.When those positions are overlaid with each variable, it can be recognized the way surili respondsto each of these variables. However,thesecorrelations cannot explain properlythe whysurilioccurred in a certain area. It is entirely possible that the existence of suriliis caused by many factors which are interrelated and influencial to each other (multicollinearity). Thus, the influence of each factor can be best understood by looking at its contribution to the formation of a new variable or Principal Components/PCs.

(a) Physical Factors

Factors that are grouped into physical factorsare distance from rivers, elevation and slope. The minimum distance from rivers, elevation and slope is 0 meter, 236 meters and 2 degrees,respectively. While the maximum valuesare 361.25 meters, 1271 meters and 48 degrees. From the distribution of data, it can be seen that the closer to rivers there is a tendency of more surilioccurence.This may be due to the river condition at the study site is located in a steep valley, with good forest cover.

In connection with the elevation and slope, surilidid not provide a consistent response to the increase in slope and elevation.This may be related to the fact that suriliis an arboreal animal and still be able to adapt to the height range of the study sites. At a certain slope and elevation, the occurrences of surili seem to decrease (Figure 5).
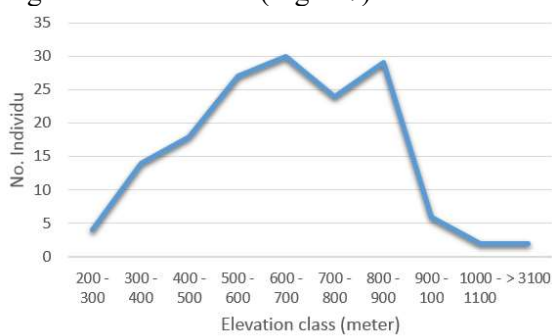
(b) Biological Factors

Minimum values of bare soil Index and NDVI at the point of surili encounteredwere77 and 0.155, respectively. Meanwhile maximum valueswere98 and 0.47 respectively.Response ofsurili to Bare soil Index and Normalized vegetation index is inversely proportional. The higher the bare soil, the less of numbers ofsurili found, while the higher the NDVI, the moresurili found (Figure 6a, b).Distance from the nearest forest is 0 meters (in the forest) and the farthest is 573.15 meters. Distribution of the data shows that the farther from the forest the less number of pointsof surili presence (Figure 6g).

Minimum values of density of all kinds of trees and feed treesare, respectively, 202and 14individuals per hectare, while the maximum valuesare, respectively, 734 and 389 trees per hectare. Pattern of distribution of the data shows that the higher the density of trees,the less the point where surili presents. Conversely the higher the density of food trees, the more points of surili encountered (Figure 6c, d)
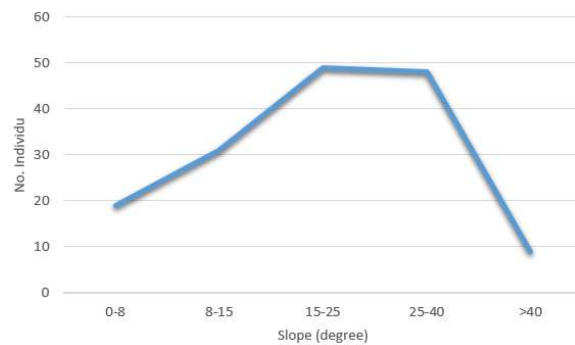
Minimum basal areas of trees and feed treesare, respectively, 7.8 square meters and 1.3 square meters. Whereasmaximum valuesare, respectively, 73.1 square meters and 28.37 square meters. Surili's responses to the basal areas of trees and to feed trees are the same, i.e. the higher the basal area the less the point of encounter of surili (Figure 6e, f). This fact shows that the actual preference of surilitowards the basal area is not linear. Probably, the preference towards the basal area decreases at a certain value.
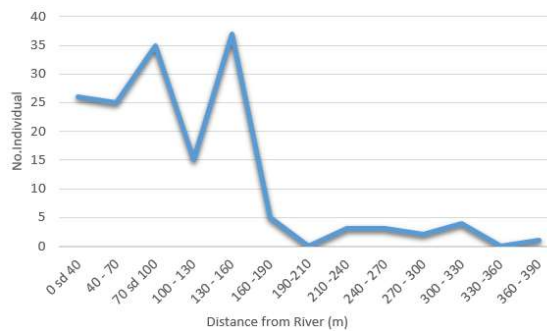
(c) Distance from human activity

Factors related to human activity is represented by distance from roads, residential and farmland. Although suriliis known as shy animal and tend to avoid humans, our observation data shows that this animal did not avoid human activities. The minimum distance of surilipresence from roads, residence and farmlandis, respectively, 0 meter, 30 meters and 0 meter. While the maximum distance of surili presence from roads, residential and farmland is 1776.09 meters, 3552.41 meters and 982.7 meters,respectively. From the data, there is a trend that the closer to the roads, residence and farms, the more the points of surili encounter. Many things that might explain this, and among them is the habit of local people who do not bother or expel the surili compared with that of to macaques. In addition, the roads in the research location are small roads whichare located onsteep slopeswherecanopies of trees are still interconnected. Similarly, the location of the community residence and farms areat the edge of mixed forests (Figure7).
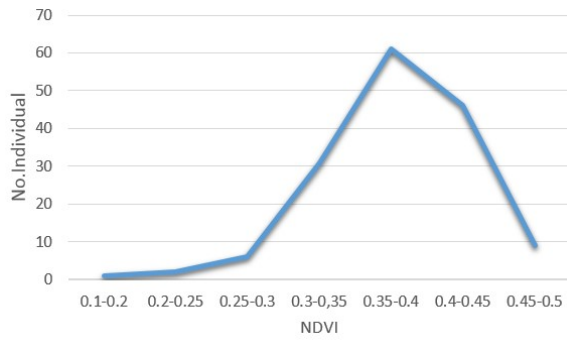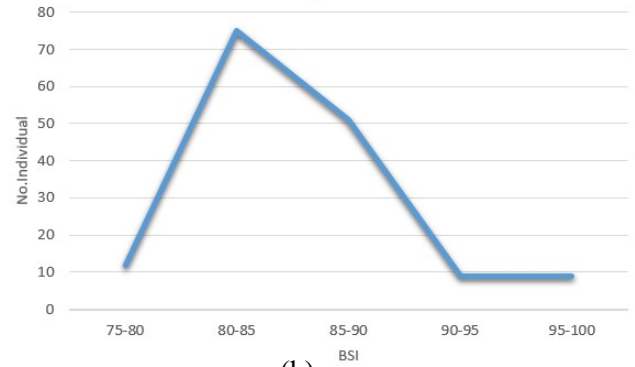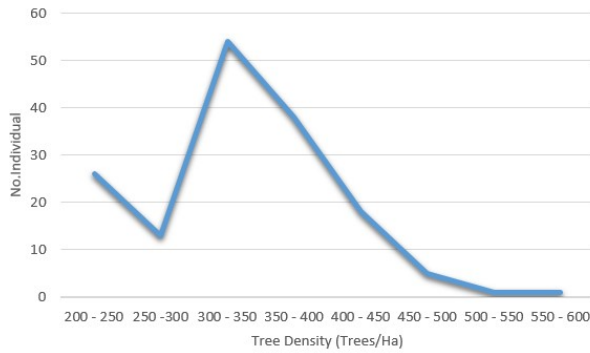

(a)

(b)

(c)

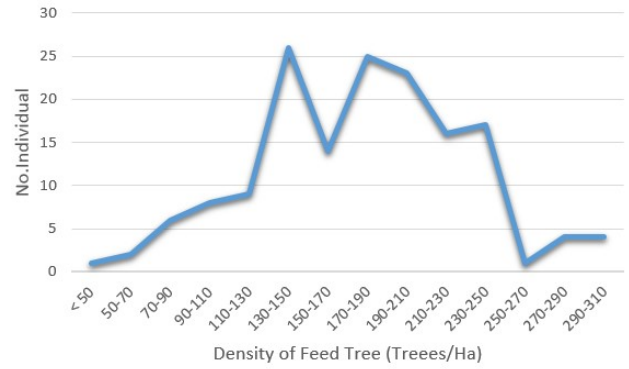**Figure 5**. Number of Surili with regard to Physical variables (a) Elevation, (b) Slope and (c) Distance to River
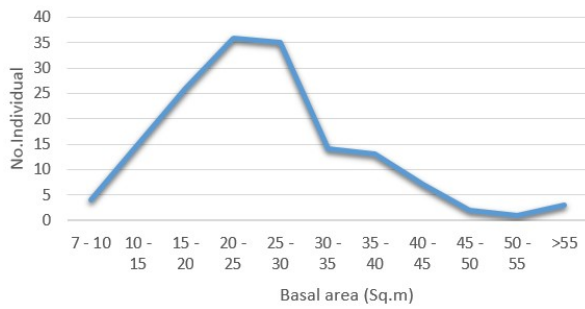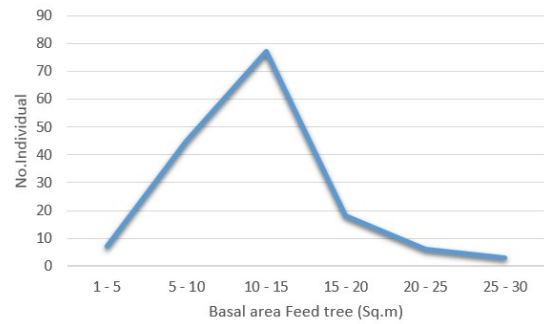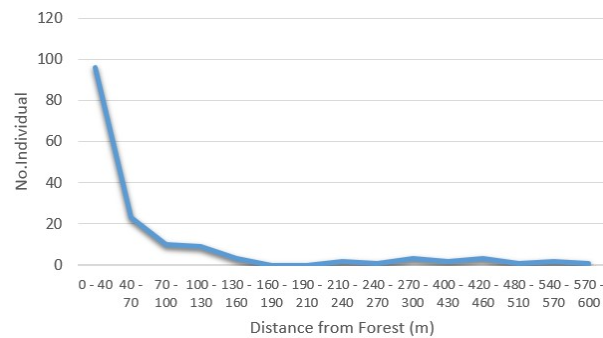

(a)

(b)

(c)

(d)

(e)

(f)

(g)

Figure 6. Number of Surili on various Biological factor variables (a) NDVI, ((b) BSI, (c) Tree density, (d) Feed tree density, (e) Basal area of trees, (f) Basal area of feed trees, (g) Distance from Forest
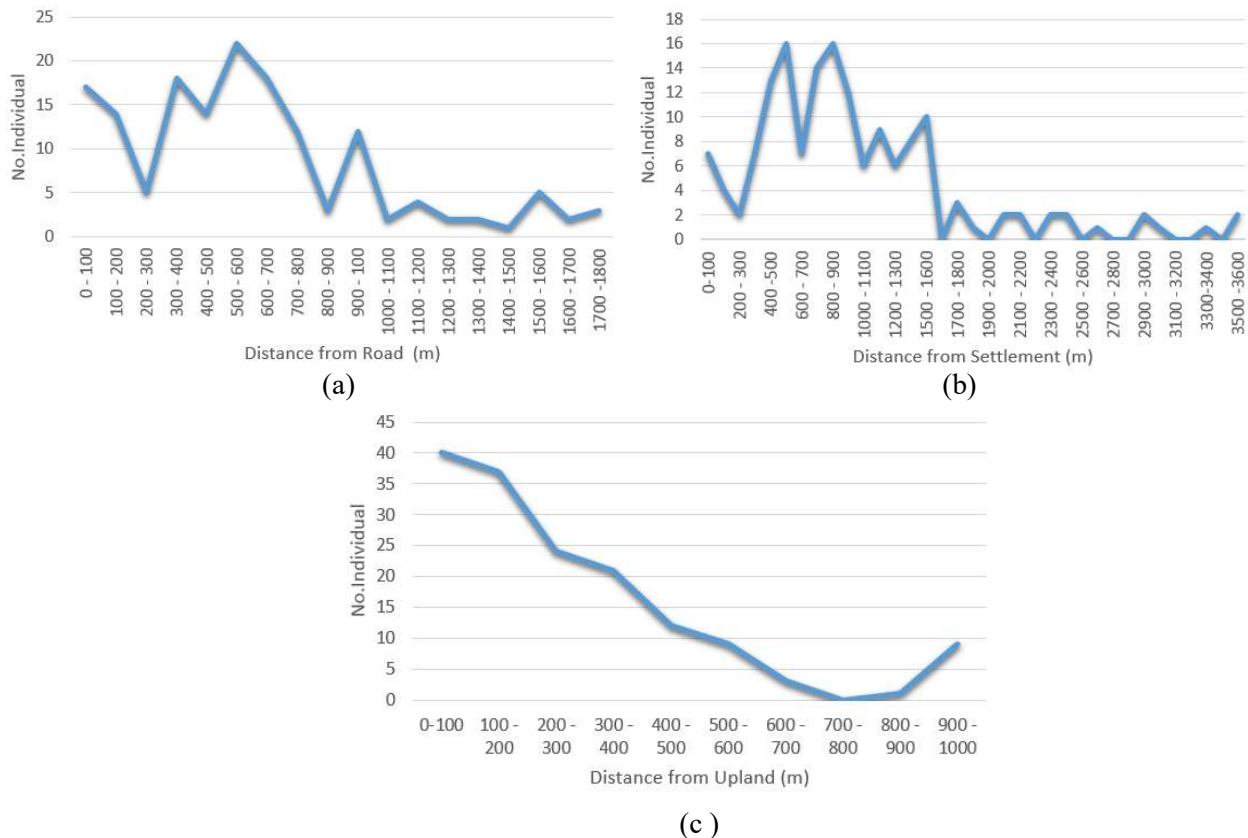

(a)

(b)

(c)

Figue7. Number of surili on human disturbance factor (a), distance from road, (b) distance from settlement and (c) distance from farms/upland

3.2. PCA Calculation Results

A total of 152 points of surili were recorded,98 points from this data wererandomly selected to build the model, whilst 54 points used to validate the model. The random selection of the points is conducted by using ArcGIS software. Operation of PCA is performed 3 times of analysis to get an acceptable value in accordance with Table 1, so that the analysis can be continued.

Number of factors that have communalities value larger than 0.5 and having correlation greater than 0.5 are 10 factors, namely BSI, elevation, distance from roads, distance from farms, distance from forest, distance fromresidence, distance from rivers, NDVI, basal area of trees and basal area of feed trees. Thus, the ratio between the number of observation and the variables is 9.8: 1. In addition, KMO value as much as 0.655 and Bartlett's test of Sphericity with a significance level of 0.00.

There were4 PC selected, and each of them has an Eigenvalue of greater than 1. In cumulative PC 1, PC 2, PC 3 and PC4 contribute as much as, respectively, 33.512%, 19.677%, 14.88% and 11.367%, and the total four PCs can explain 79.44% of the data variance. PC1 through PC4 haveloading factors of3.351, 1.968, 1.489 and 1.137,respectively,(Table 2).

When we examine further it appears that each PC represents different factors. From the contribution of each factor of its original variables (Table 3), the PC 1 explains the role of human disturbance factors which positively correlated with the presence of surili, that is the farther from the road and settlement the more suitable the habitat for the surili. This new variables explain that surili is

still very sensitive to human activities. This fact is in contrast to when we see only partial human disturbance factors in the above description.

Table2. Variance contribution

Component	Initial Eigenvalues		
	Total	**% of Variance**	**Cumulative %**
1	3.351	33.512	33.512
2	1.968	19.677	53.189
3	1.489	14.888	68.077
4	1.137	11.367	79.444
5	.798	7.982	87.426
6	.369	3.694	91.119
7	.293	2.928	94.047
8	.271	2.710	96.757
9	.195	1.949	98.706
10	.129	1.294	100.000

Table 3. Rotated Component Matrix

Variable	Component			
	1	**2**	**3**	**4**
BSI	-.231	-.860	-.206	-.066
NDVI	.166	.908	-.004	.109
Distand from road	.887	.166	.049	.175
Dist_settlmtn	.919	.119	-.181	-.034
Distance from upland	.566	.402	.470	.261
Elevation	.069	.208	.830	.178
Distance from Forest	.254	-.381	-.735	.164
Dist_river	.008	-.363	.623	-.049
Lbds_Trees	.054	.112	.066	.897
Lbds_Food	.115	.039	-.029	.906

On the PC 2 there are two original influential variablesnamely the BSI which is correlated negatively, and the NDVI factorwhich is positively correlated. This means that the lower the Bare Soil Index and the higher the NDVI, the more suitable the habitat for surili. Both of these factors are consistent with the initial analysis.

On the PC 3,factors that have high contribution are elevation, distance from rivers and forest. The distance from rivers and the elevation appear to be more in explaining that a place that is relatively far from human activities are more suitable. Likewise, the distance from the forest which negatively correlated, suggesting the role of forests as protection. The farther a spot fromforest, the more unsuitable it is for habitat of surili.

PC 4 reflects the need of surili on feed and cover which is represented by the values of basal area of feed trees and basal area of all species of trees (Table 3).

3.3. Habitat Suitability Index and Its Accuracy

Result of HSI calculations indicates that the location is dominated by areas with low HSI, which are located in areas that are relatively lower area relatively flat which dominated by upland agriculture with high disturbance from road and settlement. While high HSI are located at locations with high elevation and slope, good forest cover, and relatively far from residence, roads and upland agriculture/farms (Figure 8). The location is spatially fragmented, thus maintaining forest connectivity betweenthose locations becomes very important.

Figure 8. HSI of surili

If the HSI is divided into 5 classes, then most of the area study is unsuitable and poorly suitable, meanwhile, only small suitable area situated in forest area on hilly area (Figure 9 and Table 4). The overlay between point for validation (54 points) showed that 18 points (33.33 %) located on not suitable, 28 points (51.85 %) on Poorly suitable area, 7 points (12.96%) located on Moderately suitable and 1.85 % on suitable areas.
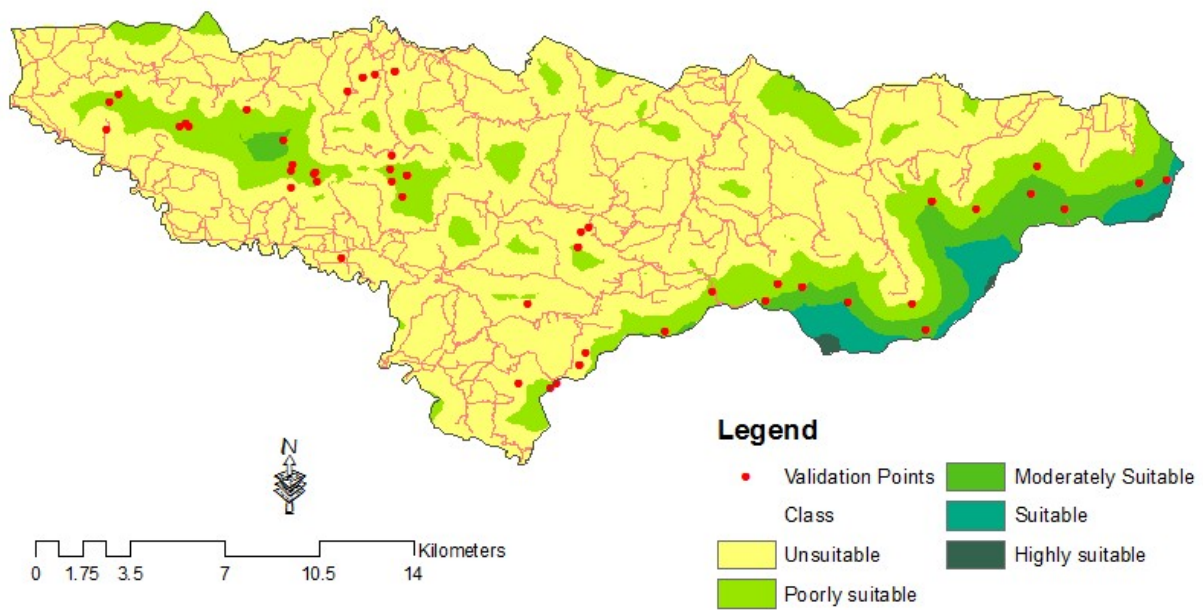
Figure 9. Suitability habitat class of surili

Table 4. Suitability class of surili

Class	Area (Ha)	Percentage (%)
Unsuitable	27,292.84	75.05
Poorly suitable	6,075.19	16.71
Moderately Suitable	1,926.53	5.30
Suitable	996.63	2.74
Highly suitable	73.61	0.20
Total	36,364.81	100.00

4. Conclusion

Surili occurrence is influenced by disturbance factor (distance from road, settlement and upland), followed by biological factor (BSI & NDVI), Physical factors (elevation, forest and distance from river) and cover and feed. The HSI could be developed based on 4PC and showed that the study area mostly is occupied by low HIS Index or not suitable area for surili.

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Habitat Suitability Index (HIS) of Surili (*Presbytis comata* Desmarest, 1822) in mixed forest of Kuningan District, West Java-Indonesia

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Habitat Suitability Index (HIS) of Surili (*Presbytis comata Desmarest, 1822*) in mixed forest of Kuningan District, West Java-Indonesia

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Abstract. Java has been experiencing deforestation due to high population pressure. A lot of natural forests which play an important role as wildlife habitat are loss. The remaining natural forest distribute in mountainous areas in the form natural conservation area, meanwhile the others have been converted into settlement andinfrastructure, food crops, cash crops plantation, estate and private forest plantation. Javan langur (*Presbytiscomata*) is an endemic species of Java and used to utilize natural forest as their habitat. However, in a recent observation the species isfound inside plantation forest in Kuningan district, West Java. This is a unique finding, due to the fact that a plantation forest is not suitable habitat for Javan langur. The research is aimed to develop Habitat Suitability for this species based on physical, biological and human disturbance factors. Data on Javan langur presence and its habitat component were derived from field observation and secondary data/map. Result showed HSI could be developed based on 4 PC and showed that the study area mostly is occupied by low HIS Index or not suitable area for surili.

1. Introduction
Surili is an endemic species of Java Island and found only in West Java and Central Java[1] [2]. This is one of endangered species [3]and listed in the Appendix II of CITES and protected by Indonesian government through Government Regulation No. 7/1999. Indonesian Ministry of Forestry incorporates this species into itslist of conservation priority species (Ministry Regulation No.P.57/Menhut-II/2008).Based on Hoogerwerf (1970) [4], this species is mainly foraging insidenatural forest. In addition,Suriliwas found in highland natural forest of Mount Halimun [5] [6] [7], Mount Salak [8], Mount Gedeand Pangrango [2], Mount Ciremai[9] [10][11], Nature Reserve of Mount Tukung Gede [12] and lowland natural forest in Ujung Kulon [13]. However, recent records show that suriliis also found in mixed forest, which is a mixture of secondary forest, pine plantation and agroforestry adjacent to agricultural land and human settlement in Regency of Kuningan [14]. This discovery is very interesting to be studied in-depth because the fact of the distribution mentioned aboveis different from the nature of suriliwhich is very sensitive to human disturbance as well asto feedand habitat preferences in natural forests. Perhaps this is one of adaptation strategies applied by the surili in a state of urgency, due to the existence of natural forests that are drastically reduced, degraded and fragmented. There is a necessity to investigaterelationshipsbetween the existence of the species on the

one hand and various variables of components of habitat that affect the distribution of surili on the other hand, both abiotic (elevation, slope) and biotic (feed, cover) components and disturbance from human activity, so that one can predict or map levelsof habitat suitability of surili in form of index on a landscape scale. This is important as a basis for conservation of species, habitat and risk management.

In spatial term, thedetermination of habitat suitability index (HSI) can be done by overlaying a variety of thematic maps, and spatial analysis can be done either in subjective or objective manners. Subjective spatial analysis can be done by simple weighting in which the amount of weight is determined based on the justification of researchers (expert judgment) or by an expert panel with Analytical Hierarchy Process approach.Objective analysis can be done by statistical analysis, especially if the relationship between the presence of this species andthe habitat component is unknown yet. Information on the ecology of suriliis very limited compared to the other primates species.

Among other statistical analysis are linear regression, general linear model/GLM/Logistic regression, and Multivariate. Recently, there is a developmentof an analysiswith approach of Machine Learning Method including ANN, Genetic Algorithm and Maximum Entropy. The chosentechnique of spatial analysis depends on the availability and types of data, both independent and dependent variable data.In cases of studies of wildlife that are always moving, in many cases one reliesmerely on the data of the species presence, thus it limits the choosing of methods of analysis. In addition to using Maxent, analytical technique that can be used isPrinciple Component Analysis/PCA. PCA is a technique to reduce and create new variable (Principle Component) based on original variables. The study aims to determine factors that influence the distribution of surili and to establishHSI models by using PCA.

2. Methodology

2.1. Study area
The study was conducted in the southern part of KuninganRegencythat bordering with CiamisRegency, CilacapRegency and BrebesRegency in the south (Figure 1). Land cover is dominated by pine plantations, secondary natural forests, agroforestry and agricultural fields (dry fields and paddy rice fields). The pine plantation forest and the natural forest are managed by Perhutani, while the agroforestry gardens are a form of community forests owned by local community. The community forest is planted with various species of trees either timber or fruit such as: sengon (*Paraserianthesfalcataria*), mahogany (*Swieteniamahagoni*), teak (*Tectonagrandis*), bitter bean (*Parkiaspeciosa*), and jackfruit (*Artocarpusheterophyllus*) [15].

2.2. Design of HSI prediction model
HSI prediction model is done by using an approach of Principle Component Analysis (PCA). The geo-location where surilifound were recorded. Independent variables (factors) thatmight play important roles in determining the existence of surili at the study area were extracted. The data of suriliwere divided into two groups. The first group is used to develop the model, while the second group is used to validate the model.There are 13 factors used in this study categorized as physical factors (elevation, slope, distance from river), biological factors (Normalized Difference Vegetation Index/NDVI, Bare soil index/BSI, tree density, density of feed trees, Basal Area/BA of feed and all trees, and distance from forest patch), and human disturbance (distance from settlement, distance from farms and distance from settlement). The value of each factor/variable for each observation was extracted using spatial analysis tool in ArcGIS software.
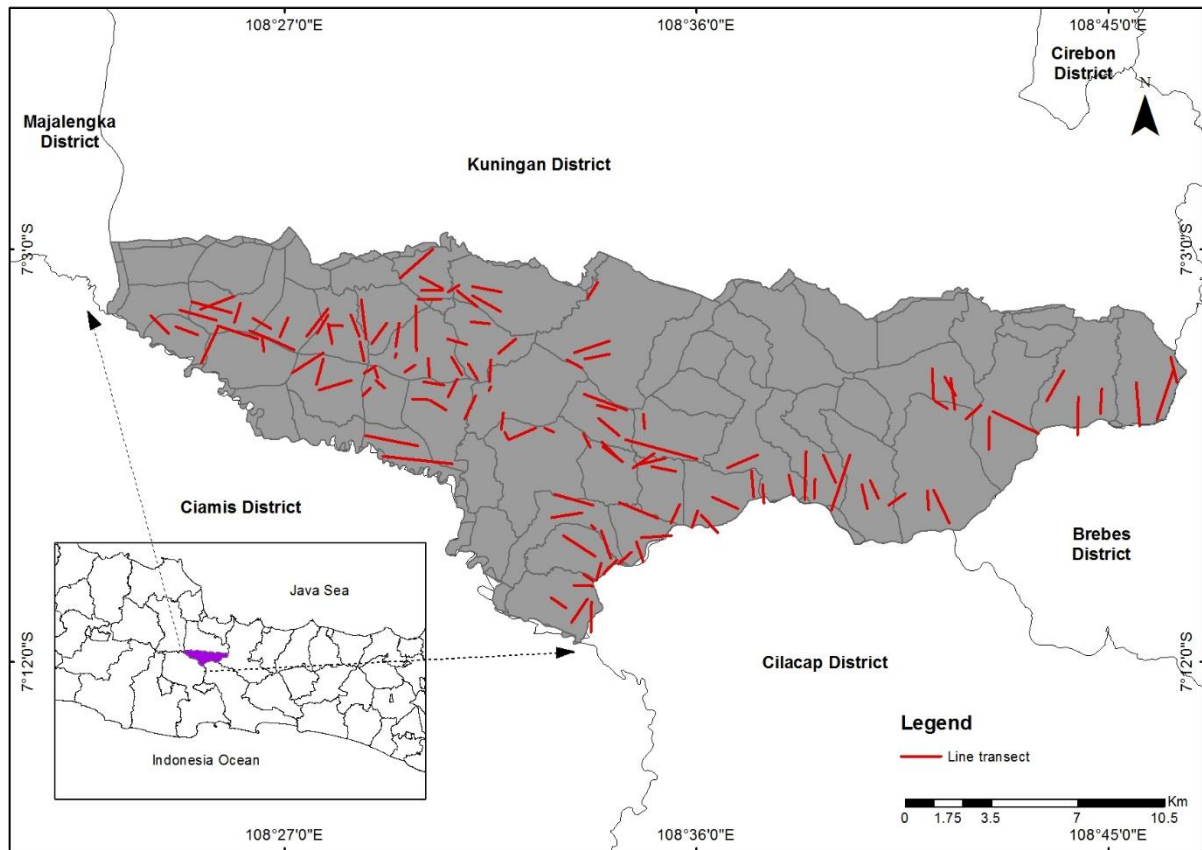
Figure 1. Study Location

PCA calculation results are considered appropriate if they meet several criteria, as presented in Table 1.

Table 1. Criteria and minimal requirement of PCA

Criteria	Minimal requirement
Ratio of observation number to variables	5 : 1[16]
Presence of substantial correlation	Some correlation greater than 0.30[17]
Sampling adequacy for individual variables	Acceptable if greater then 0.5[17]
Sampling adequacy for set variables	Acceptable if greater than 0.5[17]
Barlet test of sphericity	Less than 0.001[17]
Communalities	Greater than 0.5[18]
Total variance of the original variables	Between 70 – 90% [19]

PCA operation is repeated until all of the minimum requirements in Table 1 are met. After these minimum requirements arefulfilled, it will calculate number of newly formed variables (Principle component/PC) based on eigen value of bigger than 1. Total score is obtained by summing the PC multiplied by each of loading factor, with a general formula as follows:

$$Score = \sum_{i=1}^{n}(LF_i * PC_i) \tag{1}$$

Where:
LF_i: Loading factor of i^{th}PC
PCi: i^{th} PC
Afterward, result of the calculation in the form of floating number is spatialized and converted into HIS index scale of 0-1by using ERDAS Imagine software.

2.3. Surili existence survey

The purpose of the survey is to obtain the informationof suriliand its geo-locations. Initial information of surili presence is obtained from local community members. Subsequently, the survey is designed by using line transect method [20] [21]. The survey is started in the morning (around 6:00 am) until noon (around 12:00 pm), an investigator is walking slowly on existed paths or paths that are made available for observation [22]. Total length of transect in each forest is 5-6 km and the length of each track is 0.5-3 km. Length of each tractis adjusted to the width and the vast of the area of the forest block. Placement of transect in each forest depends on the distribution of forest and cover types as well as accessibility. This arrangement is made because the forest areawhere the research is located has a very steep topography with a lot of ravines (Figure 2).

2.4. Physical variable (elevation and slope)

2.4.1. Elevation and slope
Elevation and slope variables are generated from Digital Elevation Model (Aster G DEM) with a spatial resolution of 30 m (http://earthexplorer.usgs.gov/) by using Erdas Imagine software (Figure 2a and 2b).

2.4.2. Distance from rivers
River data of both temporal and permanent rivers is digitized based on topographical map based on a scale of 1: 25 000. Distance of existence of surilifrom riveris calculated spatially by using Euclidean Distance (ED) on ArcGIS software with spatial resolution of 30 meter (Figure 2c).

2.5. Biological variables

2.5.1. Tree density and tree basal area
Density and basal area of trees is calculated based on vegetational inventory using transect method [23]. Sample plots were established at a distance of every 100 meters (Figure 2) along surili observation transect, which is placed on each type of forest cover. The size of each sample plot is 20m x 20m [24]. Vegetation data collected includes name of tree species and tree diameter at breast height for each individual trees with diameter $\geq$ 10 cm [25].

Considering that the suriliis arboreal species [26] [27], data of undergrowth and trees with diameters of less than 10 cm were not collected. Information on the types of trees that have potential as food sources were obtained in sample plots by direct observation in the field and by studyingresults of previous studies elsewhere [26].After data of tree density and basal area of each track is obtained, then it is converted into spatial data by using interpolation technique of Inverse Distance Weight/IDW on ArcGIS software (Figure 3a, 3b, 3c and 3d).

2.5.2. Vegetation index (normalized different vegetation index/NDVI)
NDVI indicates level of greenness of earth's surface, which has continue value from -1 upto +1. Vegetation index is calculated by using data from Landsat satellite imagery 8 OLI (row/path: 121/065), which was acquired on 11 October 2015. The higher the NDVI value indicatedthe faster process of photosynthesis of those areas (Figure 3e). NDVI is calculated by using the following formula:

$$\text{NDVI} = (\text{band NIR-Red})/ (\text{band NIR} + \text{Red}) \qquad (2)$$

2.5.3. Bare soil Indeks (BSI)
This index is calculated by using the image that is used to calculate NDVI. Contrary to NDVI, Bare soil index indicates the openness of the land, which has continues value from -1 to +1, where thehigher BSI, the more open the area [28] (Figure 3f). BSI formula as follows:

$$BSI = (Band\ NIR + Band\ Red - Band\ Green)/ (Band\ NIR + Band\ Red + Band\ Green) \qquad (3)$$

2.5.4. Distance from forest patch

Forests provide foodsources, protectionfrom disturbance and predators, and facility for movement. Thus, the distance between where the suriliwere recorded and the forests is considered to be a potential variable to understand the distribution of surili in the study area. Forest cover is interpreted by using satellite images of Landsat 8 OLI (path/row: 121/065), which was acquired on 11 October 2015. Landsat interpretation was done by supervised classification technique on ERDAS Imagine software (Figure 3g).

2.6. Human activity or disturbance factors

Human disturbance factor is represented by the distance from roads, residence and farms. Road data is digitized from basic/Topographic maps with a scale of 1:25 000, while the distance from farms is based on land cover maps that were constructed from Landsat satellite image data. Distance of the presence of suriliis calculated spatially by Euclidean Distance technique in ArcGIS software (Figure 4a,4b and 4c).
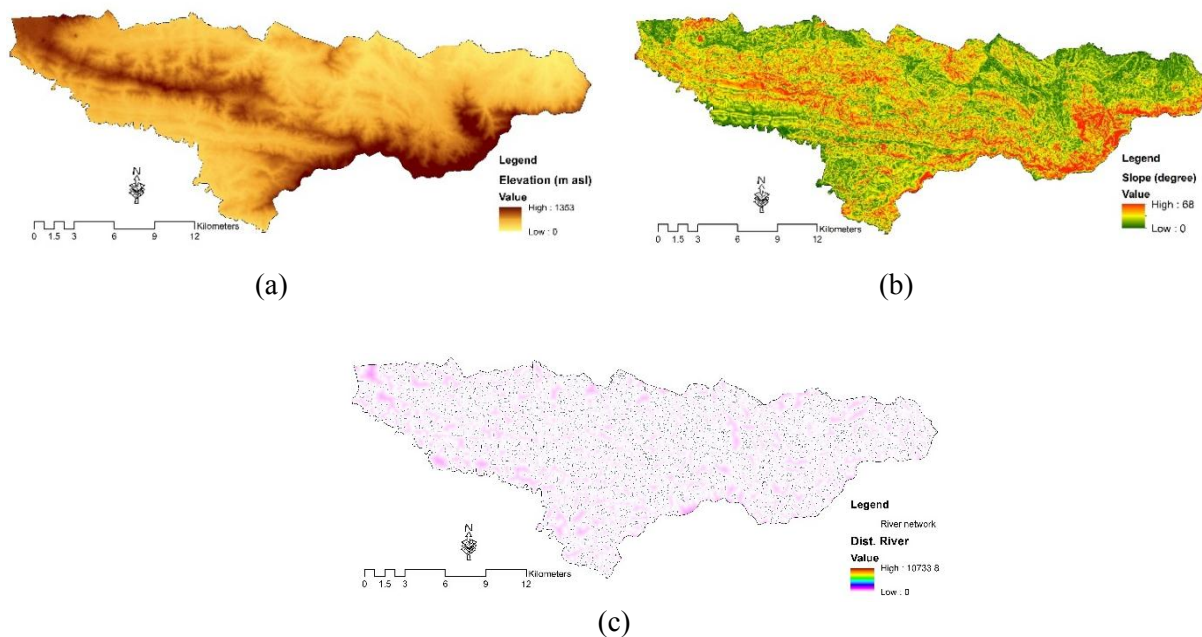

(a)

(b)

(c)

Figure2. Physical Variables: (a) Elevation, (b) Slope, (c) Distance from river
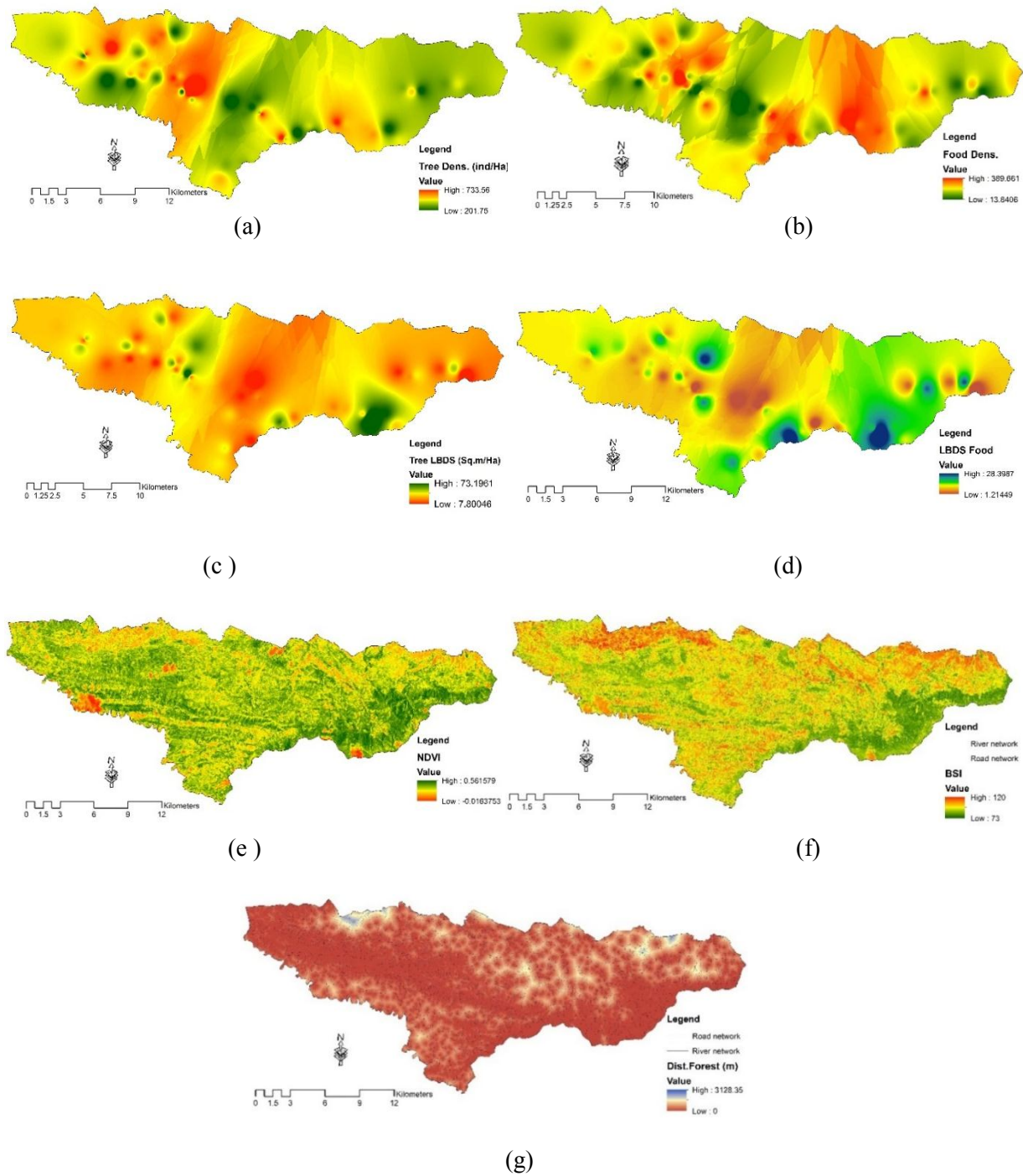
Figure 3. Biological variables: (a) Tree density (b) Feed tree density (c) Basal area of tree, (d) Basal area of feed tree, (e) NDVI, (f) BSI, (g) Distance from forest patch
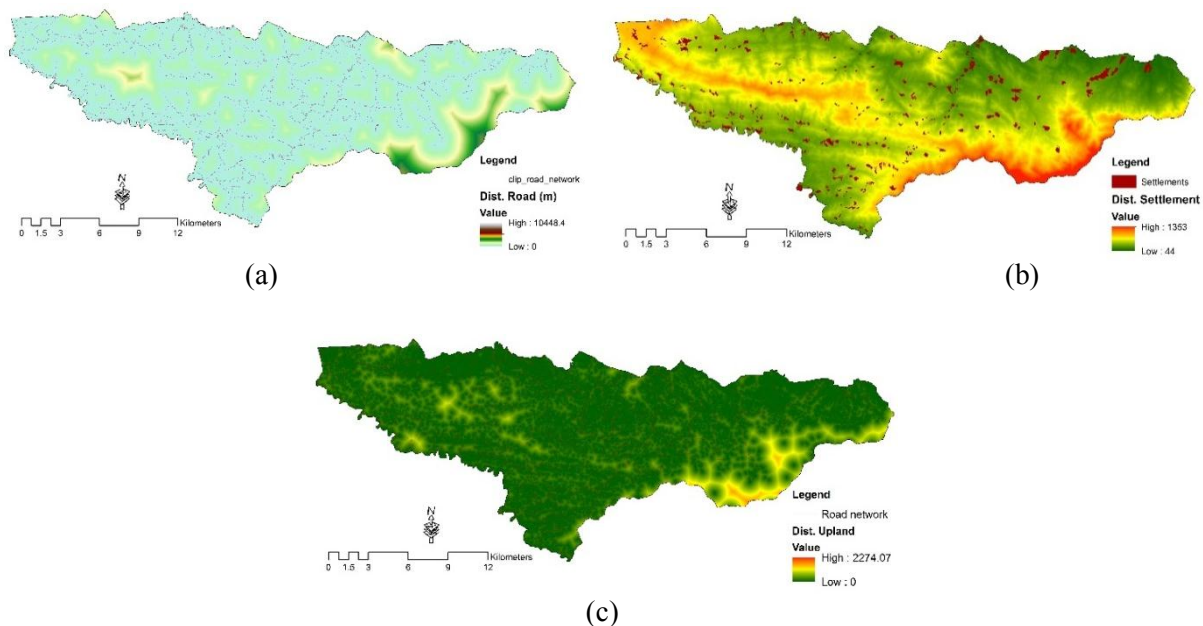
Figure 4. Disturbance Variables: (a) Distance from road, (b) Distance from settlement (c) Distance from uplands

3. Result &Discussion

3.1. Distribution of Surili

There were 156 locations of surili recorded during the survey period.When those positions are overlaid with each variable, it can be recognized the way surili respondsto each of these variables. However, these correlations cannot explain properlythe why surili occurred in a certain area. It is entirely possible that the existence of suriliis caused by many factors which are interrelated and influencial to each other (multicollinearity). Thus, the influence of each factor can be best understood by looking at its contribution to the formation of a new variable or Principal Components/PCs.

(a) Physical Factors

Factors that are grouped into physical factorsare distance from rivers, elevation and slope. The minimum distance from rivers, elevation and slope is 0 meter, 236 meters and 2 degrees,respectively. While the maximum valuesare 361.25 meters, 1271 meters and 48 degrees. From the distribution of data, it can be seen that the closer to rivers there is a tendency of more surilioccurence.This may be due to the river condition at the study site is located in a steep valley, with good forest cover.

In connection with the elevation and slope, surilidid not provide a consistent response to the increase in slope and elevation.This may be related to the fact that suriliis an arboreal animal and still be able to adapt to the height range of the study sites. At a certain slope and elevation, the occurrences of surili seem to decrease (Figure 5).

(b) Biological Factors

Minimum values of bare soil Index and NDVI at the point of surili encounteredwere77 and 0.155, respectively. Meanwhile maximum valueswere98 and 0.47 respectively.Response ofsurili to Bare soil Index and Normalized vegetation index is inversely proportional. The higher the bare soil, the less of numbers ofsurili found, while the higher the NDVI, the moresurili found (Figure 6a, b).Distance from the nearest forest is 0 meters (in the forest) and the farthest is 573.15 meters. Distribution of the data shows that the farther from the forest the less number of pointsof surili presence (Figure 6g).

Minimum values of density of all kinds of trees and feed treesare, respectively, 202and 14individuals per hectare, while the maximum valuesare, respectively, 734 and 389 trees per hectare. Pattern of distribution of the data shows that the higher the density of trees,the less the point where surili presents. Conversely the higher the density of food trees, the more points of surili encountered (Figure 6c, 6d).

Minimum basal areas of trees and feed treesare, respectively, 7.8 square meters and 1.3 square meters. Whereasmaximum valuesare, respectively, 73.1 square meters and 28.37 square meters. Surili's responses to the basal areas of trees and to feed trees are the same, i.e. the higher the basal area the less the point of encounter of surili (Figure 6e, f). This fact shows that the actual preference of surilitowards the basal area is not linear. Probably, the preference towards the basal area decreases at a certain value.

(c) Distance from human activity

Factors related to human activity is represented by distance from roads, residential and farmland. Although suriliis known as shy animal and tend to avoid humans, our observation data shows that this animal did not avoid human activities. The minimum distance of surilipresence from roads, residence and farmlandis, respectively, 0 meter, 30 meters and 0 meter. While the maximum distance of surili presence from roads, residential and farmland is 1776.09 meters, 3552.41 meters and 982.7 meters,respectively. From the data, there is a trend that the closer to the roads, residence and farms, the more the points of surili encounter. Many things that might explain this, and among them is the habit of local people who do not bother or expel the surili compared with that of to macaques. In addition, the roads in the research location are small roads whichare located onsteep slopeswherecanopies of trees are still interconnected. Similarly, the location of the community residence and farms areat the edge of mixed forests (Figure7).

(a)

(b)

(c)

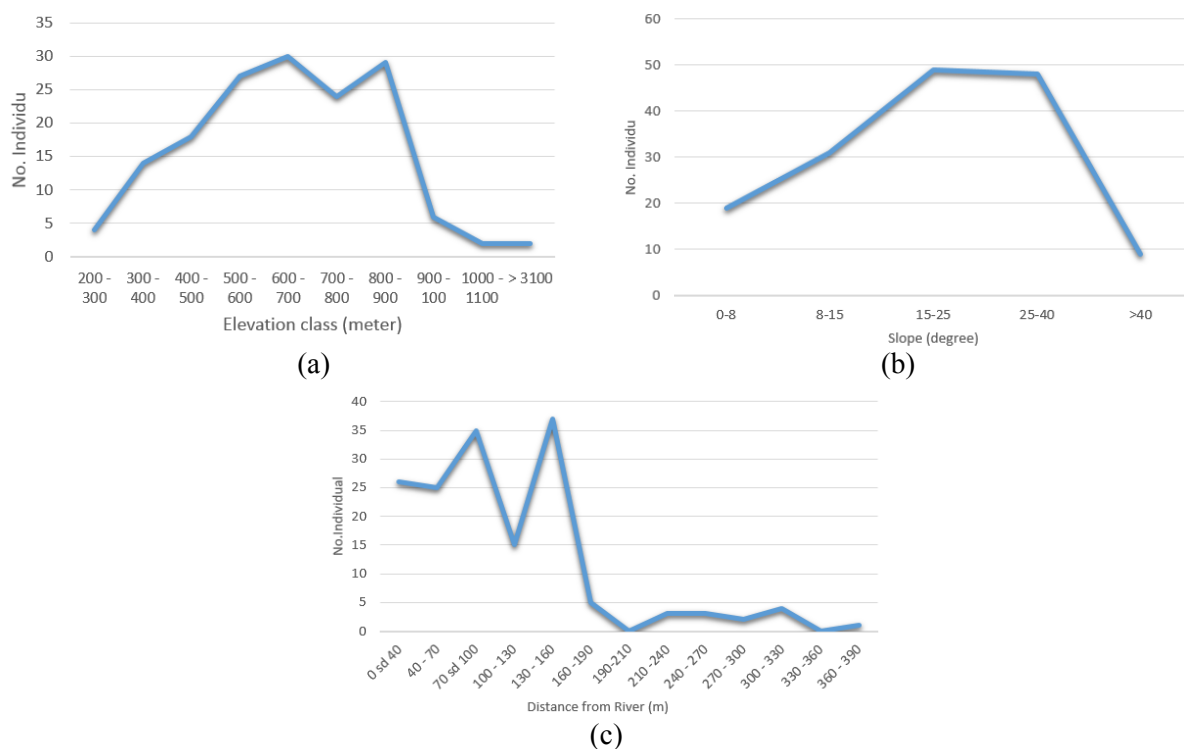**Figure 5**. Number of Surili with regard to Physical variables (a) Elevation, (b) Slope and (c) Distance to River
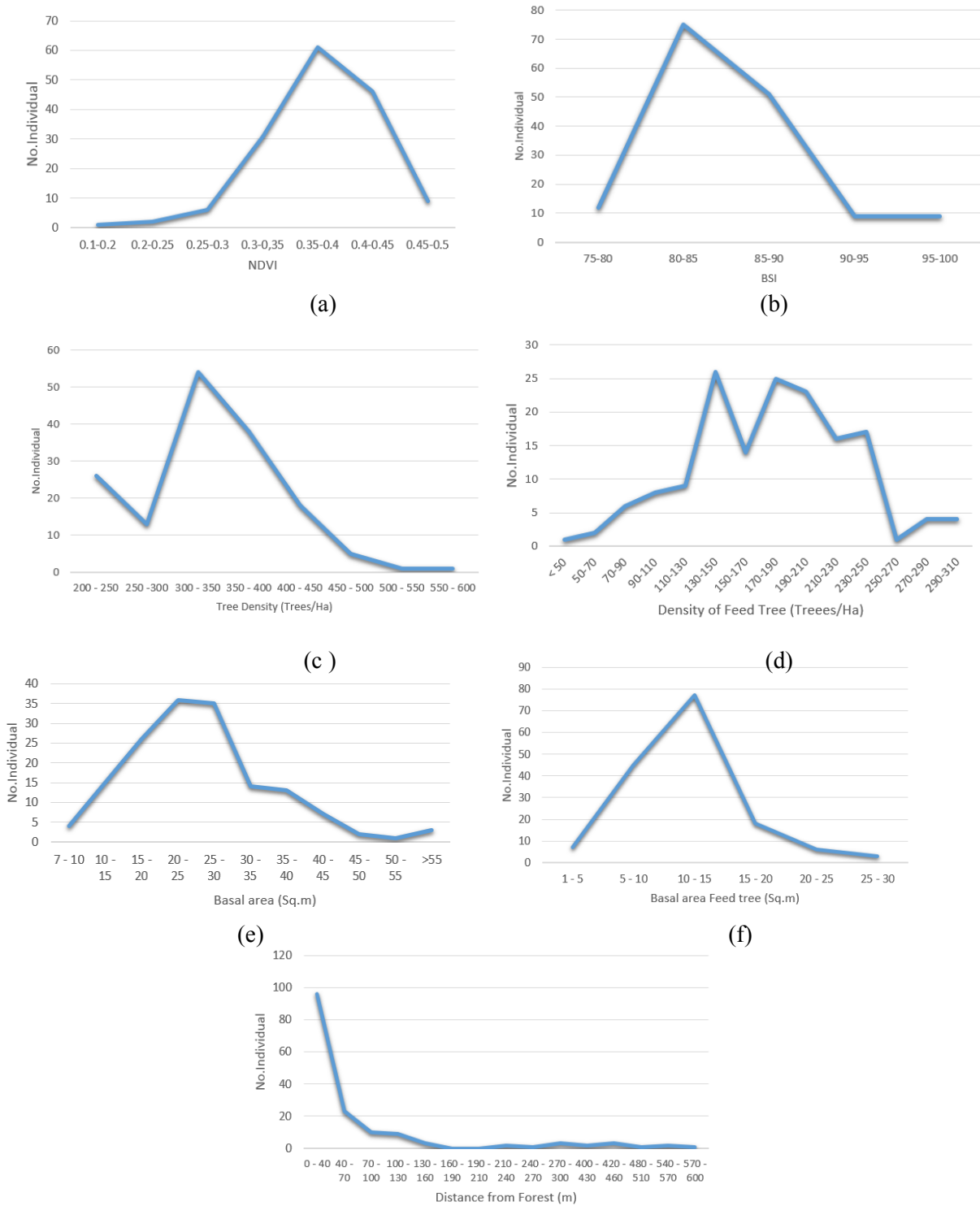
(a)

(b)

(c)

(d)

(e)

(f)

(g)

Figure 6. Number of Surili on various Biological factor variables (a) NDVI, ((b) BSI, (c) Tree density, (d) Feed tree density, (e) Basal area of trees, (f) Basal area of feed trees, (g) Distance from Forest
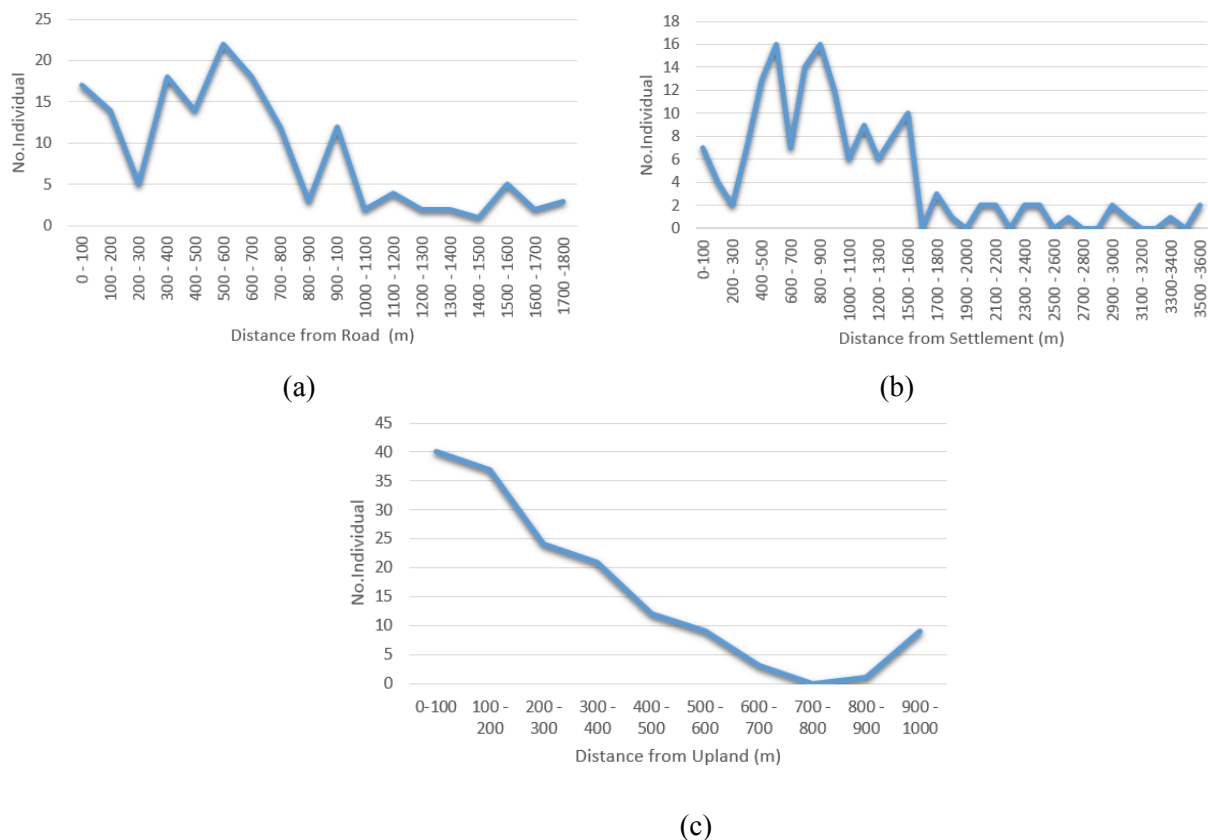
(a)

(b)

(c)

Figue7. Number of surili on human disturbance factor (a), distance from road, (b) distance from settlement and (c) distance from farms/upland

3.2. PCA Calculation Results

A total of 152 points of surili were recorded,98 points from this data were randomly selected to build the model, whilst 54 points used to validate the model. The random selection of the points is conducted by using ArcGIS software. Operation of PCA is performed 3 times of analysis to get an acceptable value in accordance with Table 1, so that the analysis can be continued.

Number of factors that have communalities value larger than 0.5 and having correlation greater than 0.5 are 10 factors, namely BSI, elevation, distance from roads, distance from farms, distance from forest, distance fromresidence, distance from rivers, NDVI, basal area of trees and basal area of feed trees. Thus, the ratio between the number of observation and the variables is 9.8: 1. In addition, KMO value as much as 0.655 and Bartlett's test of Sphericity with a significance level of 0.00.

There were4 PC selected, and each of them has an Eigenvalue of greater than 1. In cumulative PC 1, PC 2, PC 3 and PC4 contribute as much as, respectively, 33.512%, 19.677%, 14.88% and 11.367%, and the total four PCs can explain 79.44% of the data variance. PC1 through PC4 haveloading factors of3.351, 1.968, 1.489 and 1.137, respectively (Table 2).

When we examine further it appears that each PC represents different factors. From the contribution of each factor of its original variables (Table 3), the PC 1 explains the role of human disturbance factors which positively correlated with the presence of surili, that is the farther from the road and settlement the more suitable the habitat for the surili. This new variables explain that surili is still very sensitive to human activities. This fact is in contrast to when we see only partial human disturbance factors in the above description.

Table2. Variance contribution

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3.351	33.512	33.512
2	1.968	19.677	53.189
3	1.489	14.888	68.077
4	1.137	11.367	79.444
5	.798	7.982	87.426
6	.369	3.694	91.119
7	.293	2.928	94.047
8	.271	2.710	96.757
9	.195	1.949	98.706
10	.129	1.294	100.000

Table 3. Rotated Component Matrix

Variable	Component			
	1	2	3	4
BSI	-.231	-.860	-.206	-.066
NDVI	.166	.908	-.004	.109
Distand from road	.887	.166	.049	.175
Dist_settlmtn	.919	.119	-.181	-.034
Distance from upland	.566	.402	.470	.261
Elevation	.069	.208	.830	.178
Distance from Forest	.254	-.381	-.735	.164
Dist_river	.008	-.363	.623	-.049
Lbds_Trees	.054	.112	.066	.897
Lbds_Food	.115	.039	-.029	.906

On the PC 2 there are two original influential variablesnamely the BSI which is correlated negatively, and the NDVI factorwhich is positively correlated. This means that the lower the Bare Soil Index and the higher the NDVI, the more suitable the habitat for surili. Both of these factors are consistent with the initial analysis.

On the PC 3, factors that have high contribution are elevation, distance from rivers and forest. The distance from rivers and the elevation appear to be more in explaining that a place that is relatively far from human activities are more suitable. Likewise, the distance from the forest which negatively correlated, suggesting the role of forests as protection. The farther a spot from forest, the more unsuitable it is for habitat of surili.

PC 4 reflects the need of surili on feed and cover which is represented by the values of basal area of feed trees and basal area of all species of trees (Table 3).

3.3. Habitat Suitability Index and Its Accuracy

Result of HSI calculations indicates that the location is dominated by areas with low HSI, which are located in areas that are relatively lower area relatively flat which dominated by upland agriculture with high disturbance from road and settlement. While high HSI are located at locations with high elevation and slope, good forest cover, and relatively far from residence, roads and upland agriculture/farms (Figure 8). The location is spatially fragmented, thus maintaining forest connectivity betweenthose locations becomes very important.
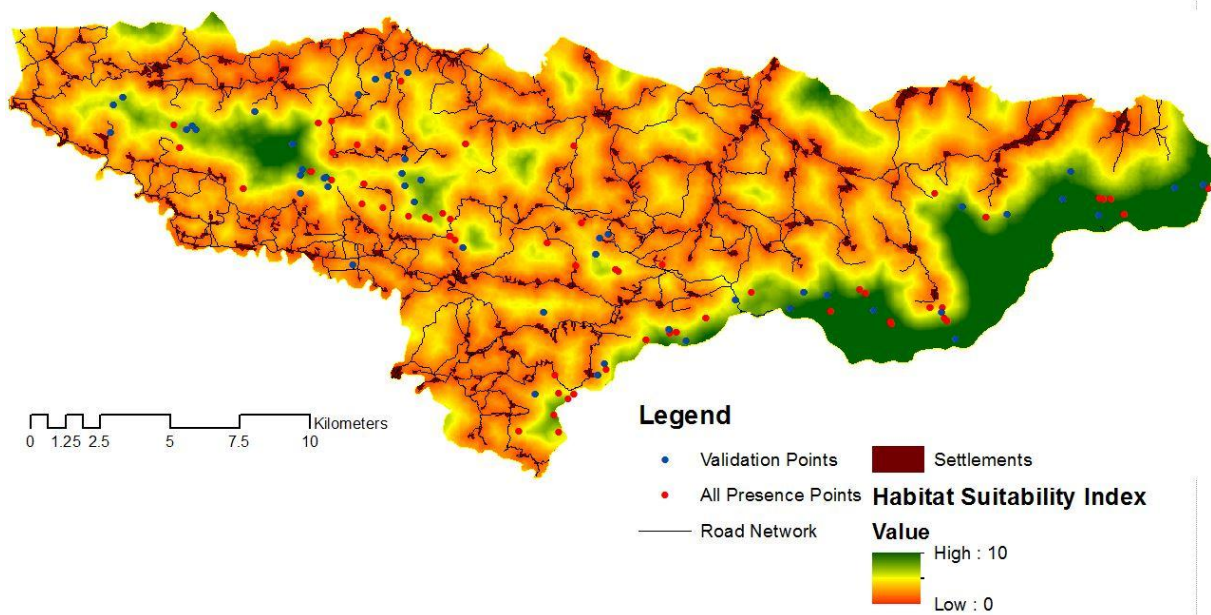

Figure 8. HSI of surili

If the HSI is divided into 5 classes, then most of the area study is unsuitable and poorly suitable, meanwhile, only small suitable area situated in forest area on hilly area (Figure 9 and Table 4). The overlay between point for validation (54 points) showed that 18 points (33.33 %) located on not suitable, 28 points (51.85 %) on Poorly suitable area, 7 points (12.96%) located on Moderately suitable and 1.85 % on suitable areas.
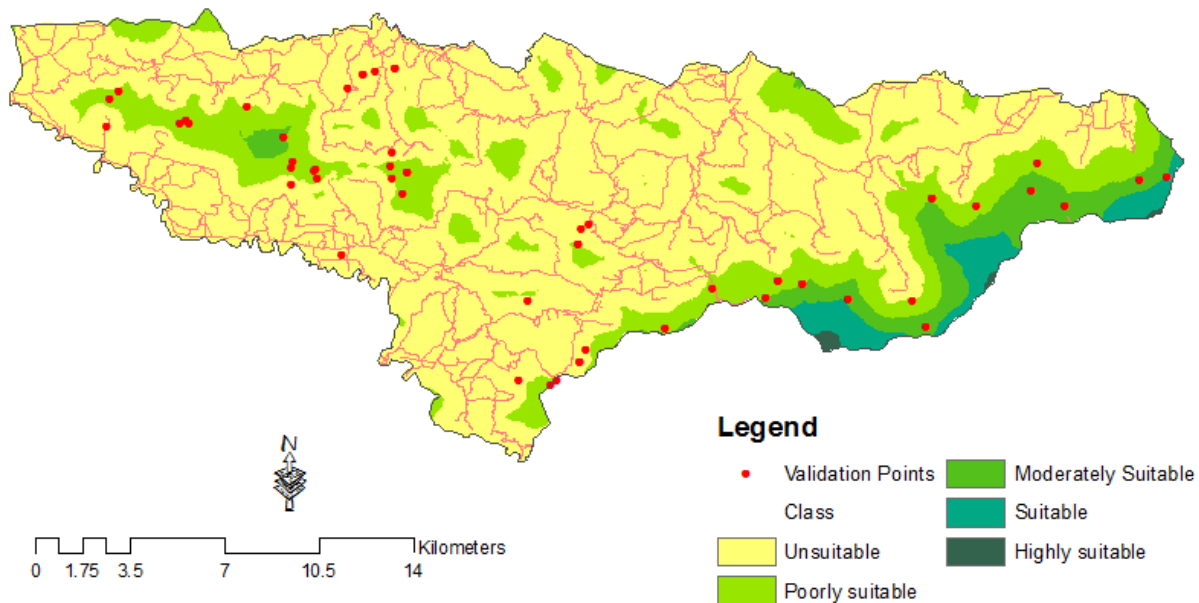
Figure 9. Suitability habitat class of surili

Table 4. Suitability class of surili

Class	Area (Ha)	Percentage (%)
Unsuitable	27,292.84	75.05
Poorly suitable	6,075.19	16.71
Moderately Suitable	1,926.53	5.30
Suitable	996.63	2.74
Highly suitable	73.61	0.20
Total	36,364.81	100.00

4. Conclusion

Surili occurrence is influenced by disturbance factor (distance from road, settlement and upland), followed by biological factor (BSI & NDVI), Physical factors (elevation, forest and distance from river) and cover and feed. The HSI could be developed based on 4 PC and showed that the study area mostly is occupied by low HIS Index or not suitable area for surili.

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