# Evaluation of natural environment using GIS for important plants (to survive in disasters)

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***ABSTRACT*****:** Earthquakes are frequently occurred in Japan. Furthermore Japan has predict a huge earthquake in the next 30 years. For this reason, the important plants will be a big role to survive in disasters. Lupines (Local Useful Plants with Intelligent Networks of Exploring Surface) has been developed by Research Organization for Regional Alliances in Kochi University of Technology in 2011. Lupines is a database for vegetation resource which has collected various data of vegetation. Therefore, growth environment of the important plants will be evaluated by GIS using Lupines. Generally, the important plants inhabit often in forest road and footpath around farmland. This study aimed to use field survey data and reference data which clarified habitat characteristics of important plants. Used reference data are categorized topography, meteorology and land surface. Mountain village map was created by spatial analysis using land cover classification. Field survey data was important data for integrating Lupines was evaluated with the reference data. Habitat suitable land of important plants was selected from characteristics of habitat of each important plant. The proposed approach could be accurate that the field survey data were increased in the future. Incidentally, reference data were insufficient, therefore the global solar radiation data of forest area could be prepared in future.

***KEYWORDS*****:** important plants, Mountain village, suitable land

## 1. INTRODUCTION

Environmental issues including global warming has become serious, the monitoring of natural environment and natural resources are becoming important.

Lupines (Local Useful Plants with Intelligent Networks of Exploring Surface) has been developed by Research Organization for Regional Alliances in Kochi University of Technology in 2011[1]. Lupines is a database for vegetation resource which has collected various data of vegetation. The collected data are name, characteristics, utilization method and information of plant seed. Moreover, the location of the vegetation is stored in the database, and added by every surveying. Normally, this database had used in evaluated of important plants habitat. The important plants were defined an edible plant to survive in disasters that earthquakes were often occurred in Japan where had predicted it is in near 30 years. The important plants was be a big role to survive in disasters; therefore, growth environment of the important plants will be evaluated by GIS using Lupines. The important plants had own characteristics in topographic feature, meteorological condition and land cover situation then characteristics of habitat of the important plants were clarified using spatial analysis on GIS.

The seven kinds of plants were shown in Table1 were selected for evaluation.

Table1. Objective plant

| | English name | Scientific name | Japanese name |
|---|---|---|---|
| **PlantA** | Japanese silverberry | Elaeagnus umbellata | Akigumi |
| **PlantB** | Japanese knotweed | Fallopia japonica | Itadori |
| **PlantC** | Japanese fig | Ficus erecta | Inubiwa |
| **PlantD** | Harlequin glory bower | Clerodendrum trichotomum | Kusagi |
| **PlantE** | - | Pueraria lobata | Kuzu |
| **PlantF** | - | Aster scaber | Shirayamagiku |
| **PlantG** | Leopard plant | Farfugium japonicum | Tsuwabuki |

The study area was shown in Figure 1 was Shikoku islands in Japan.

Figure1. Test area

## 2. DATA COLLECTION

Data collection was shown in Table 2 were categorized topography, meteorology and land surface.

Table2. Data collection

| Topography | Meteorology | Land surface |
|---|---|---|
| Elevation | Annual mean temperature | Land cover |
| Slope inclination | Year maximum temperature | Land use |
| Slope azimuth | Year minimum temperature | Mountain village map |
| Ridge or valley | Annual rainfall | |
| Landform | | |

### 2.1. Topography

#### 2.1.1. Elevation (DEM)

Elevation data (DEM) was provided by GSI (Geospatial information Authority of Japan) was shown in Figure 2 which had 10m grid size, 0.001m elevation interval and 1m accuracy.

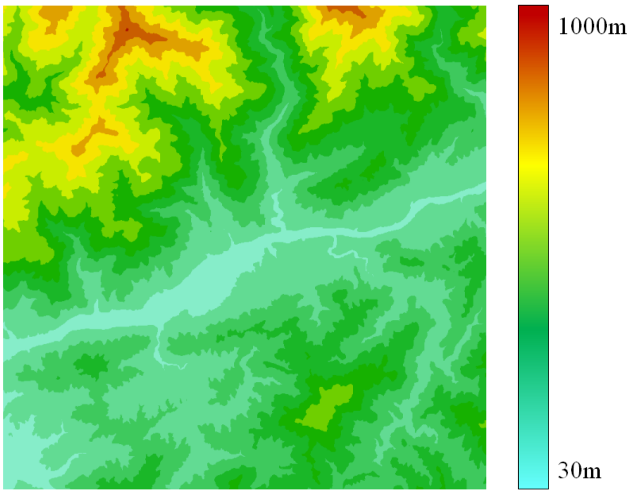


Figure2. Digital Elevation Model (DEM)

#### 2.1.2. Slope

Slope was created by QGIS (Quantum GIS) which was free open source geographic information system[2)]. The slope was shown in Figure 3 by using elevation data.

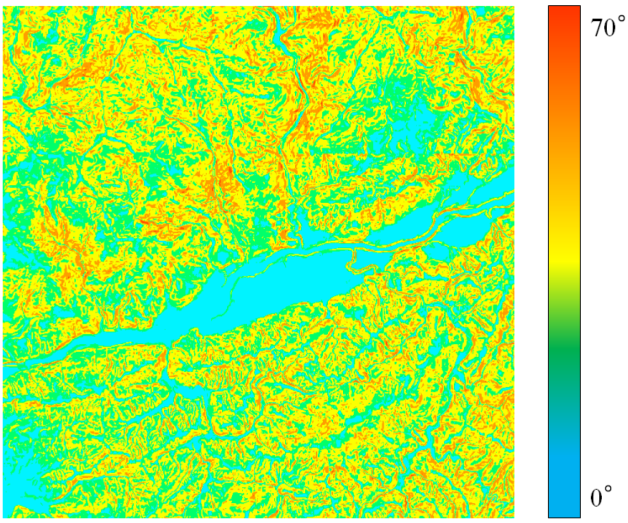


Figure3. Slope

#### 2.1.3. Flow direction

Flow direction was created by QGIS was shown in Figure 4 by using elevation data.

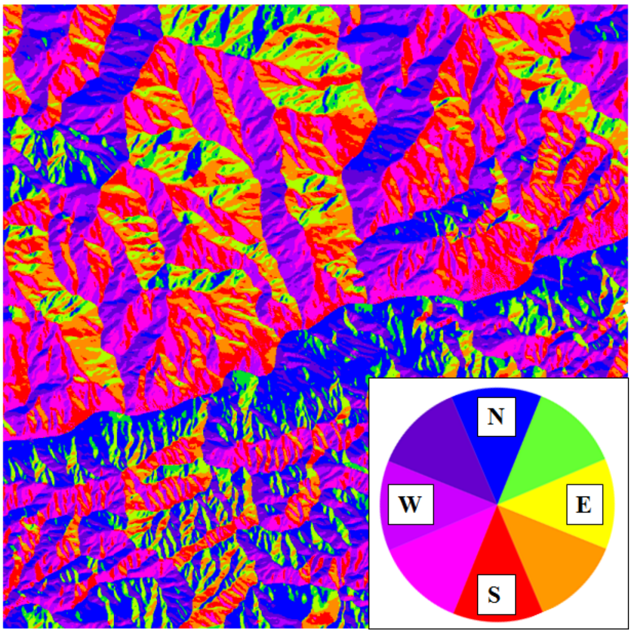


Figure4. Flow direction

2.1.4. Topography classification map

Topography classification map was created by QGIS was resample grid size to 50m.

This map was shown in Figure 5 was compared by average elevation of 10m elevation data for classification of ridge, flat and valley.

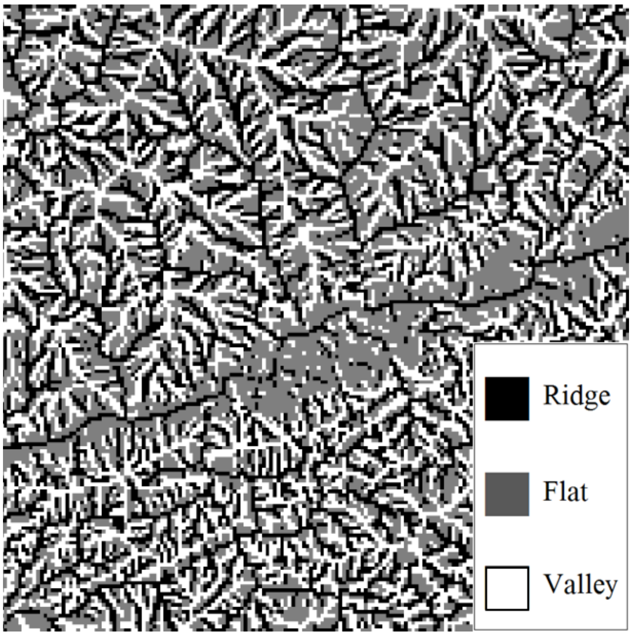


Figure5. Ridge or valley

2.1.5. Landform

Landform data are provided by MLIT[3] (Ministry of Land, Infrastructure, Transport and Tourism) (Figure 6). As shown in Figure 6 was categorized by Plateau, Hill, Mountains, Terrace and Lowland.

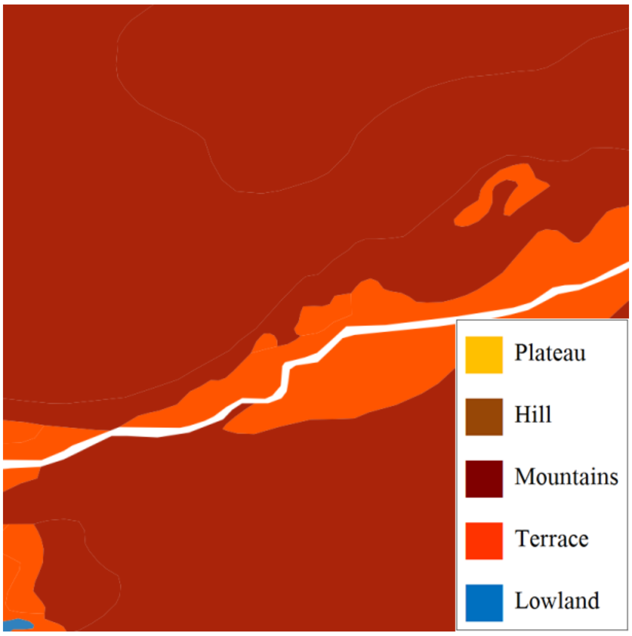


Figure6. Landform

## 2.2. Meteorology

2.2.1. Annual temperature

Temperature data were observed and calculated normal value for 30 years by JMA (Japan Meteorological Agency) and provided by MLIT.

This data had information in 1km grid size and 0.1 degree interval. The data analysis was concluded by annual maximum temperature, annual minimum temperature.

The annual mean temperature was shown in Figure 7.

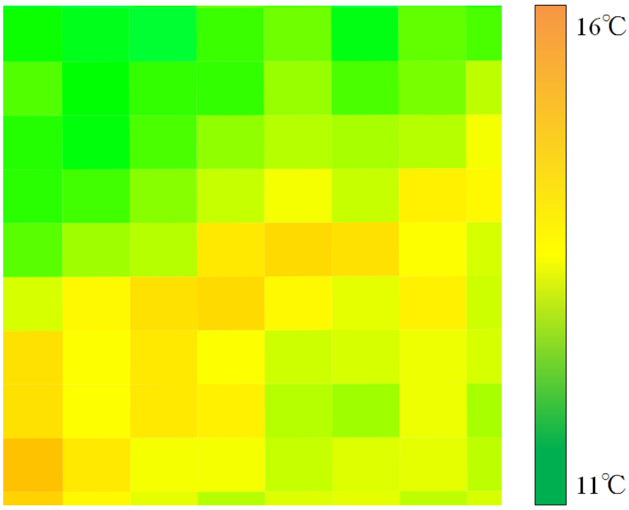


Figure7. Annual mean temperature

2.2.2. Rainfall

Rainfall data were observed and calculated normal value for 30 years by JMA and provided by MLIT.

This data had information in 1km grid size and 0.1mm interval was shown in Figure 8 of annual rainfall data.

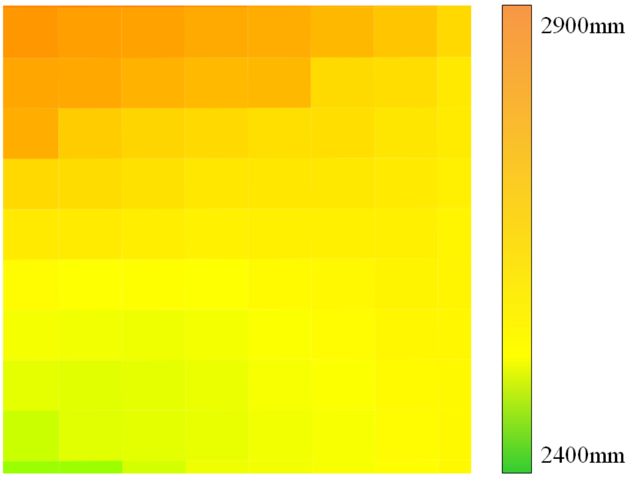


Figure8. Annual rainfall

## 2.3. Land surface

2.3.1. Land use

Land use data was provided by MLIT at 2009 was shown in Figure 9 for 100m of grid size.

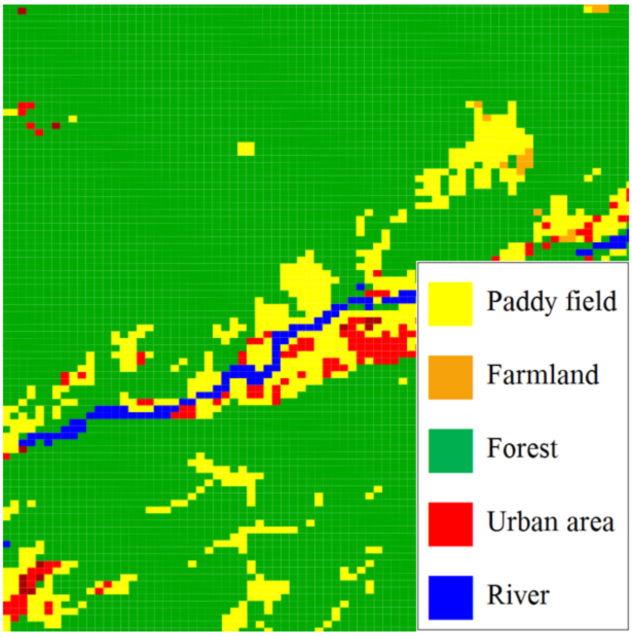


Figure9. Land use

2.3.2. Satellite data

Satellite data was ALOS AVNIR-2 at April, 7 and August, 23 2009 was used to generate land cover map in 10 m of grid size.

This data was processed radiometric and geometric correction by JAXA (Japan aerospace exploration agency).

AVNIR-2 was divided in 4 spectral band as Band 1(Visible light blue), Band 2(Visible light green), Band 3(Visible light red) and Band 4(near infrared) was shown in Figure 10 at April and August respectively

False color image was emphasized vegetation areas which was a high reflectance percentage in near infrared, therefore it was expressed using Band 4 as red color.

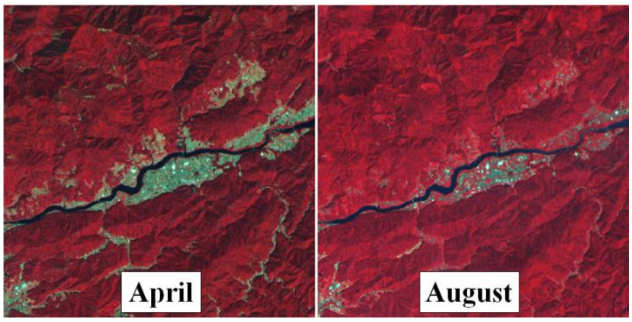


Figure10. Satellite false color data

2.3.3. Land cover

Land cover was created according to land cover classification algorithm. NDVI (Normalized Differential Vegetation Index) was used to create land cover classification algorithm was used as general index of vegetation[4]. NDVI as presented in equation (1).

$$NDVI = \frac{(IR-R)}{IR+R} \qquad (1)$$

$R$:Visible light red(Band3)
$IR$:Near-infrared(Band4)

Classification algorithm was shown in Figure 11. Satellite data in April and August were used to classify land cover. The paddy field was covered water in April and it grown by rice in August, therefore, it classified using difference of change of seasons. The land cover classification algorithm was decided by acquired NDVI value and Band4 of satellite data from visual interpretation. Then, this classification algorithm was created using threshold and seven rules[5].

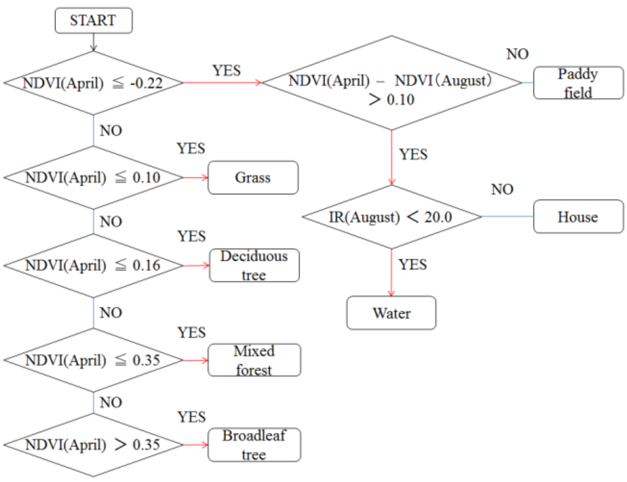


Figure11. Classification algorithm

Result of analysis by algorithm was shown in fig 12.

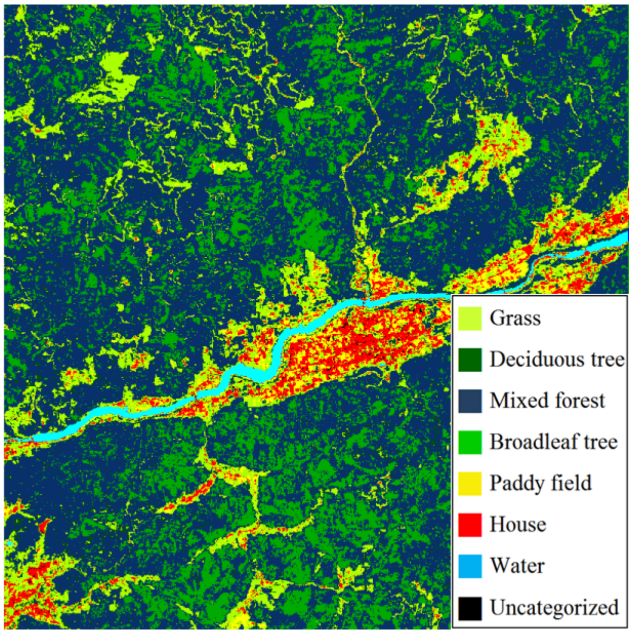


Figure12. Land cover

2.3.4. Mountain village map

The important plants inhabited often in Forest road and footpath around farmland. These places were secondary nature which was affected by human such as mowing and farmland. Mountain village was place which was located midway between nature and village. These places were environment which was constituted by village, farmland, grass and the secondary forests. It assumed that many important plants inhabit in mountain village. Therefore, Mountain village map was created by spatial analysis using land cover classification. Mountain village was decided when each 10% of house and mixed forest are occupied within 410m of window size. This window size was suited comparing with other 4 kinds of window size.

Mountain village map and Field survey data was shown in Figure 13.

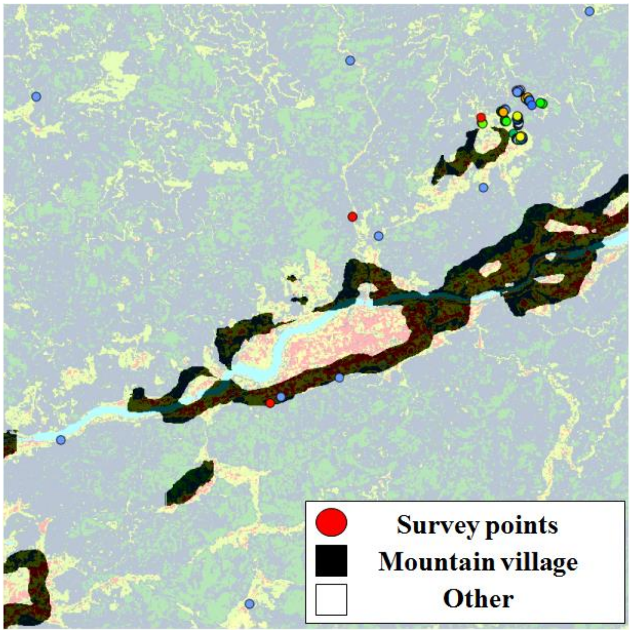


Figure13. Mountain village map

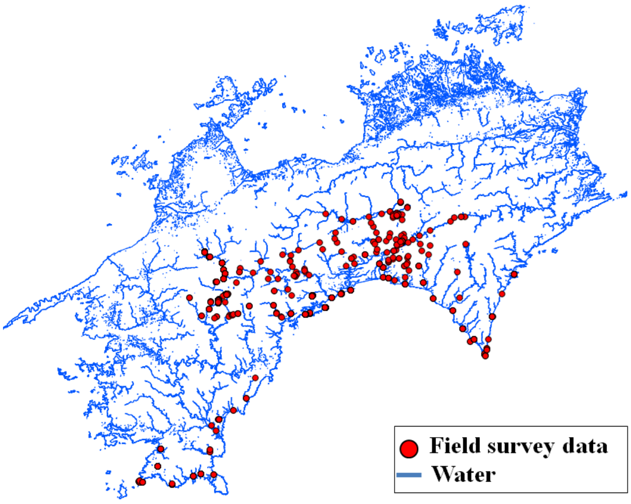


Figure14. Field survey data

## 3. FIELD SURVEY DATA

Field survey data were evaluated with reference data was data which was integrated in Lupines. Currently, 1005 field survey data were stored in Lupines. Number of kinds of plants was shown in 75 species. Location of field survey data were shown in Figure 14 by spatial distribution of field survey data in the test area.

## 4. CHARACTERISTICS OF THE HABITAT-ION

Characteristics of habitat of important plants could be discussed by general characteristics of habitat of important plant in existing publications was shown in Table 3. Each reference data at important plant were obtained using point sampling tool of QGIS. Point sampling tool could be added attribute information of reference data at specified sampling points.

### 4.1. Topography

The characteristics of topography were calculated by elevation, slope inclination, slope azimuth, topography classification map and landform. The results of elevation in each important plant were shown in Figure 15. It found that Plant C and Plant G were inhabited less than 400m of elevation. Plant A, Plant B and Plant F were inhabited in high elevation place.

Table3. General common characteristics

| | Elevation(m) | Slope aspect | Annual mean temperature(℃) | Land cover | Landform classification | Land use |
|---|---|---|---|---|---|---|
| PlantA | - | South | - | - | - | Forest, Waste Land, Riverside |
| PlantB | - | - | - | - | - | - |
| PlantC | 0~600 | - | 9~16 | - | Mountains, Hill, Piedmont area | Forest, Coast |
| PlantD | 0~1700 | South | - | - | Mountains, Hill, Piedmont area | Forest, Waste Land, Riverside |
| PlantE | - | South | - | - | - | - |
| PlantF | - | South | - | Grass, Forest | Mountains, Hill | Forest, Waste Land |
| PlantG | 0~500 | - | 9~16 | - | Plain, Mountains | Forest, Waste Land, Coast |

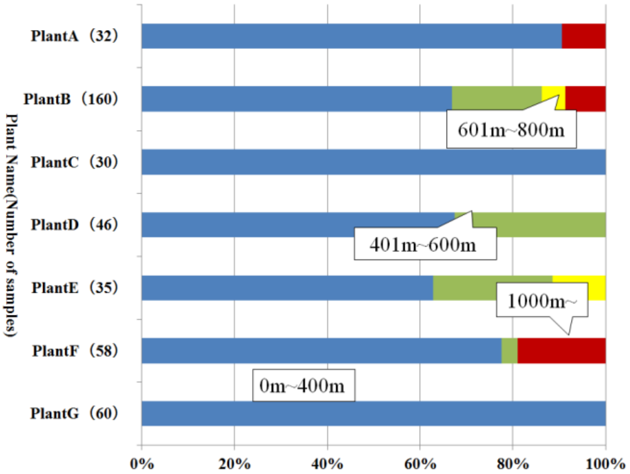


Figure15. Spatial distribution on Elevation data

The topographic characteristics of each important plant were shown in Table 4. Plant D, Plant F and plant G are located within 20 degree on slope inclination.

Table4. Topographic characteristics

| | Elevation(m) | Slope inclination(°) | Slope azimuth | Ridge or Valley | Landform |
|---|---|---|---|---|---|
| PlantA | - | - | - | - | Plain~Low mountains |
| PlantB | - | - | - | - | - |
| PlantC | 0~400 | - | - | - | Plain~Low mountains |
| PlantD | 0~600 | 0~20 | - | Flat, Ridge | Plain~Low mountains |
| PlantE | 0~800 | - | East | Valley, Flat | - |
| PlantF | - | 0~20 | Northwest | - | - |
| PlantG | 0~400 | 0~20 | - | - | - |

## 4.2. Meteorology

Meteorological condition was important for all plants.

Annual range between maximum and minimum temperature was especially important for each plant. Meteorology characteristics of habitat of each important plant were shown in Table 5. Plant A, Plant B and Plant F were inhabited in location of various temperatures. Plant B and Plant G were inhabited on large difference with maximum and minimum temperature.

Table5. Meteorological characteristics

| | Annual mean TEMP(℃) | | Annual amplitude of TEMP Change(℃) | | Annual rainfall(mm) | |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| PlantA | 7.8℃ | 17.6℃ | 6.4℃ | 10.1 | 1991.8 | 3041.1 |
| PlantB | 7.8℃ | 17.5℃ | 5℃ | 10.9 | 1980.9 | 3404 |
| PlantC | 13.3℃ | 17.5℃ | 5.2℃ | 10.7 | 2113 | 2891.1 |
| PlantD | 12.8℃ | 16.7℃ | 7.5℃ | 10.6 | 2047.9 | 3167.5 |
| PlantE | 10.1℃ | 17.5℃ | 5.8℃ | 10.8 | 1980.9 | 3190.9 |
| PlantF | 8℃ | 16.5℃ | 9.2℃ | 10.7 | 2047.9 | 3106.5 |
| PlantG | 13.4℃ | 17.5℃ | 5 | 10.9 | 2038 | 3404 |

## 4.3. Land surface

### 4.3.1. Land cover and Land use

Spatial distributions of the important plants were clarified on land cover and land use. Figure 16 and Figure 17 showed the obtained results of land cover and land use.

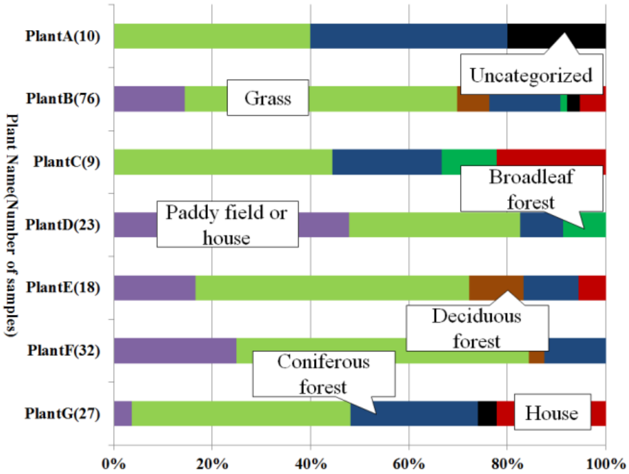


Figure16. Spatial distribution on Land cover

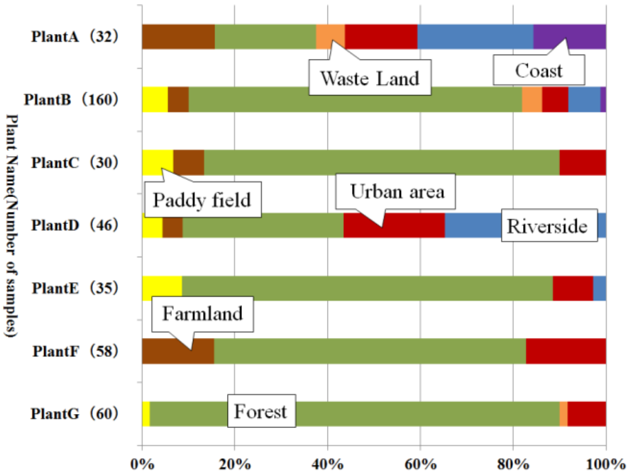


Figure17. Spatial distribution on Land use

Plant A was located in grass and mixed forest. Plant D was located in grass and paddy field. Other plants were located in various places of land use.

### 4.3.2. Mountain village map

The important plants inhabited near Mountain village therefore, spatial analysis of mountain village using buffering tool in QGIS were performed. Buffering was an analysis method which was analyzed distance of certain range. As the results, 80% in each plant inhabited within 1000m from Mountain village.

## 5. SUITABLE LAND

Habitats suitable lands of each plant were selected from previous all characteristics of each important plants however, habitat of Plant B has almost no characteristics. Therefore, habitats suitable land of Plant B was impossible to select. In contrast, Plant C and Plant G have particularly characteristic. Figure 18 and Figure 19 shows habitat suitable land of plant C and plant G.

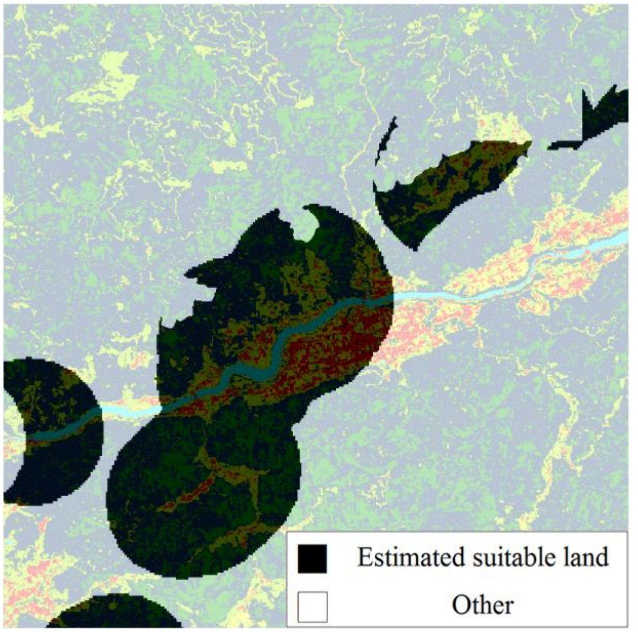


Figure18. Suitable land Plant C in Shikoku

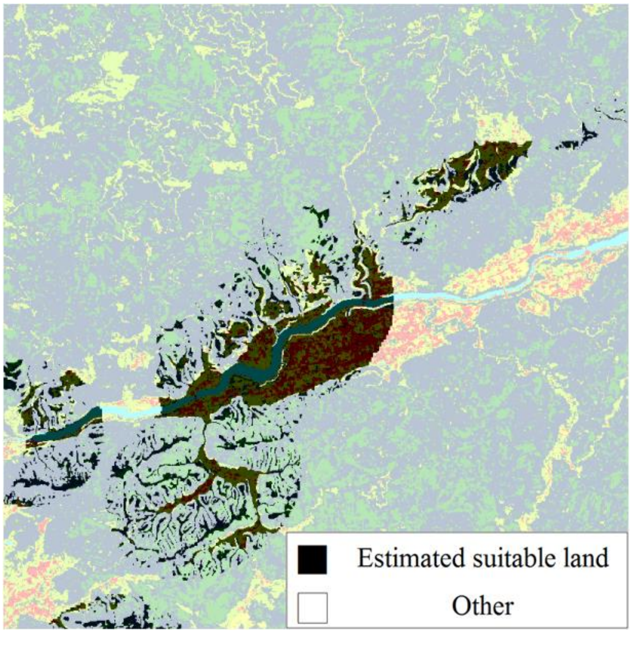


Figure19. Suitable land Plant G in Shikoku

Furthermore, general habitat suitable land of important plants were selected using characteristics in Table 3.

Moreover, 2 kind of habitat suitable land of important plant were compared was shown in Figure 20 and Figure 21 by overlaid 2 kind of suitable land of important plant about Plant C and Plant G.

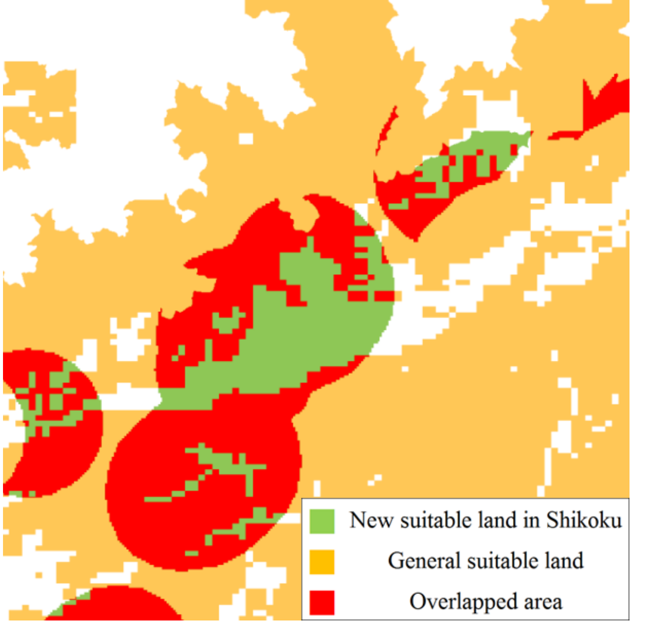


Figure20. Comparison of suitable land (Plant C)

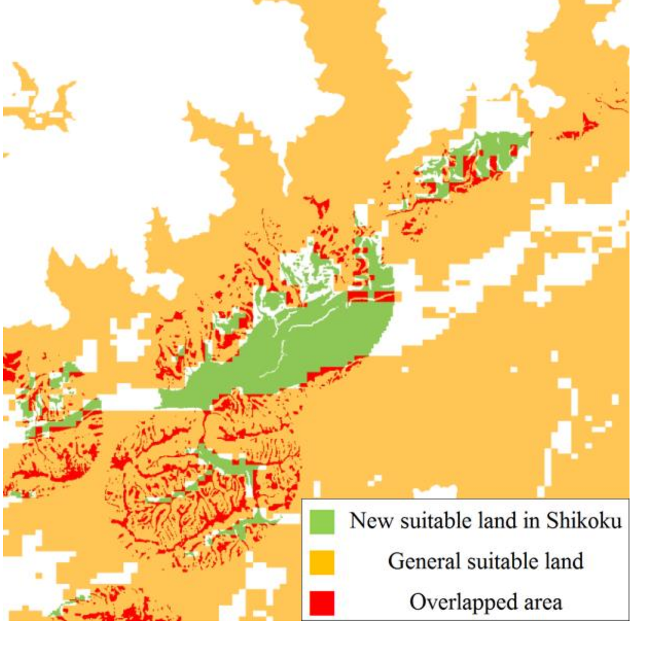


Figure21. Comparison of suitable land (Plant G)

Habitat suitable land 79% in Shikoku of Plant C was overlapped on general habitat suitable land of Plant C. On the other hand, habitat suitable land 56% in Shikoku of Plant G was overlapped general habitat suitable land of Plant G.

Furthermore, general habitat suitable land and field survey data were compared. Table 7 by results of comparison of field survey data and general suitable land.

This study area was covered by Plant C & Plant G approximately 80%. And other plants approximately 40%.

Therefore, the results suggested that general habitat suitable land could be applied to habitat suitable land in Shikoku islands about Plant C and Plant G. However, other plants have much different with general suitable land in the test area. These plants might be influenced by other items.

Table7. Comparison of Field survey data

| Plants name(Number of sample) | Number of overlapping | Percentage |
|---|---|---|
| PlantA(22) | 0 | 0% |
| PlantC(30) | 25 | 83% |
| PlantD(42) | 17 | 40% |
| PlantE(35) | 6 | 17% |
| PlantF(58) | 4 | 7% |
| PlantG(60) | 53 | 88% |

## 6. CONCLUSION

In this study, characteristics of habitat of important plant were clarified using field survey data and reference data. Habitat suitable land of important plants was selected from characteristics of habitat of each important plant. However, habitats suitable land of Plant B was impossible to select. It is speculated causes that Plant B was inhabit anywhere. In contrast, Plant C and Plant G were especially characteristics which was compared with general habitat suitable land of important plants. The results, Plant C and Plant G were found to inhabit location of general suitable.

General suitable land might not be used by using quantitative data. In the future, the field survey data were obtained increase, the result will be accurate.

By the way, reference data were insufficient that land cover was covered only part of the Shikoku island. Land cover of whole of Shikoku island was necessary to create.

Habitat distribution of each plant is deeply related with solar radiation data in forest floor.

The global solar radiation data of forest floor must be prepared in future.

## REFERENCES


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