A RESOURCE ANALYSIS ON SOLAR PHOTOVOLTAIC GENERATION BY A REMOTE SENSING APPROACH

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ABSTRACT

A planning of large-scale PV system installed in a desert has been studied. This study has defined the conditions of estimation for suitable land in order to set up large-scale photovoltaic with remote sensing. Basis requirements for the land selection of PV systems are considered that the land surface should be flat and rigid and should not move like sand dune, mountain and river basin are also excluded. Authors show the identified examples of a flat ground, a sand dune and mountain by the combination of types of processed images, i.e. the image which is presumed as conglomerate desert, the image which is presumed as desert steppe, and the image which is extracted as an edge line by using various filters. So far, we could indicate that a detail classification algorithm for right land is developed. It is concluded that this proposed method can provide sufficient information for the planning of PV system installations.

1.INTRODUCTION

In late years, the energy demand in the world is continuing the increase with the economic growth in the world, and the increase in population. It is certain that the primary energy in the world is drained by an increasing number of energy demands in the world. Additionally, various environmental problems, such as global warming, desertification, and acid-rain issue will also increase in connection with it. In the inside of such a world background, PV systems are treated as important from the point which does not discharge carbon dioxide at the time of power generation. In order to save the energy problems, a planning of large-scale PV system installed in a desert has been studied, and has been a focus of constant attention. Irradiation in a desert is very strong, it is a suitable land area for large-scale photovoltaic. Therefore former project is thought that play an important role in a future energy source. However very unstable land like a sand dune is not suitable for installation of PV system. The area which is suitable for PV system is not a sand desert but a conglomerate desert. The conglomerate desert consists of flat land and no vegetation area. Consequently, estimation for suitable land is needed. The desert has been analyzed from the remote sensing which is suitable for investigating a wide area, and the land that is suitable for installation was selected. In addition, Authors established the method of selecting the land which can install a PV system. Authors demonstrated an efficacy of technique for investigating the suitable area of PV system installations by using remote sensing.

2.MATERIALS AND METHODS

2.1 Test Site

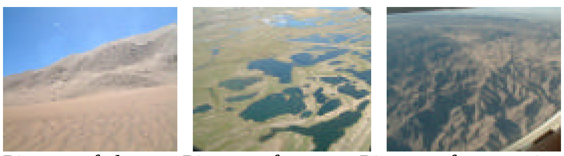
Gobi desert is very vast, first, the test site was located in Gobi desert, in Mongolian southern part as in Fig.1. The approximate geographic coordinates are 40° 30' N, 102°30' E. Since the information on a spot existed, this area was made into the test zone. In fact, Gobi desert has many types of land surface as in Fig.2. Table 1 shows a optical sensor images of JERS-1 launched in 1992 (Table1). JERS-1, an earth observing satellite that provides global coverage, is used for national land surveys, agriculture and forestry assessment, environmental protection, disaster prevention, and coastal monitoring, with a focus on resource management. Fig.3 shows these images. Forest zone and removing area such as a sand dune zone is not most suitable zone, it is the priority matter of this study.

Table 1. Main Characteristics of JERS-1

JERS-1 Optical Sensor (OPS)	
Spectral Band Visible and Near-Infrared	band 1 0.52 to 0.60 µm band 2 0.63 to 0.69 µm band 3 0.76 to 0.86 µm
Ground Resolution	18.3m×24.2m
Swath Width	75 km

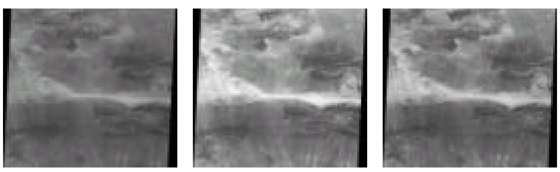
Test site (The point on a map) Detailed map

Fig.1 Area for research



Picture of dune Picture of water Picture of mountain

Fig.2 Land surface of Gobi desert



band 1 band 2 band 3

Fig.3 Three channels images of JERS-1[1]

2.2 Vegetation Index

First, Authors calculated a Modified Soil Adjusted Vegetation Index (MSAVI) in order to get to know more about vegetation state of whole test zone. MSAVI was calculated using reflectance values from two channels (NIR:860nm, RED:672nm). The MSAVI comprises density and quantity of vegetation. In more depth, when the vegetation cover has a low density, normally the soil reflectance increases in both the red and infrared channels. To describe more adequately this soil-vegetation system, other indices were proposed. To minimize the effect of bare soil, the Modified Soil Adjusted Vegetation Index was developed by Qi et al[2].

$$MSAVI = \frac{2NIR + 1 - \sqrt{(2NIR+1)^2 - 8(NIR - RED)}}{2} \qquad (1)$$

2.3 Training area

Secondly, authors classified the surface of Gobi desert into six patterns from satellite image according to Visual Evaluation Standard of Natural Color. Natural Color image is a composed image with blue and red filters applied on in two visible bands and a green filter on in a near-infrared band. Forests and grasslands displayed in bright green and city areas, in magenta. It is different from actual color. At this point, six patterns are a dune, conglomerate desert, desert steppe, forest, and water area. Authors identified the areas as training areas. Visual evaluation standard is displayed in Table 2. Authors calculated MSAVI against training areas and demonstrated an efficacy of technique for surface estimation by visual evaluation standard.

Table 2. Classification of Gobi desert

Color of satellite images	Surface of Gobi desert
Green	Forest , Steppe
Yellow	Desert Steppe
Magenta	Conglomerate Desert
Black line	Dune
Black	Water

2.4 Maximum Likelihood Classifier

Thirdly, authors classed surface of Gobi desert into six patterns with the use of Maximum Likelihood Classifier (MLC). MLC is known as a classification technique.

$$L(x,c) = \frac{1}{(2\pi)^{K/2} \left| {}_cV \right|^{1/2}} \exp\left\{ -\frac{1}{2} d^2{}_M(x,c) \right\} \qquad (2)$$

C : classification class
$L(x,c)$: likelihood
$d^2_M(x,c)$: Maharanobis distance
${}_cV$: covariance matrix

When L(x,c) becomes maximum, unit of images is classified into the class C. Authors decided parameters of MLC. And these parameters are a reflection level of band1, reflection level of band1+2+3, and MSAVI.

2.5 filtering of satellite images

Suitable areas for PV system installation must be a flat surface. And so Edge lines were detected from satellite images with the use of Laplacian filter. Edge lines indicate mountains and undulating plain from satellite images. These undulating plains were extracted with the use of this filters. Hereby, flat areas were extracted. In a continuing series, authors dealt with image that is extracted edge lines through process of dilatation and constriction. Herewith, authors painted the circumference of the neighborhood where the edge line was extracted all white.

2.6 Integration of analysis images

Finally, authors integrated three processed images into one image and estimated areas with no vegetation, a little vegetation, flat, not water basin. Hereby, Suitable areas for PV system installation were obtained.

Fig.4 Informational integration

3. RESULTS AND DISCUSSION

3.1 Calculation results from MSAVI method

MSAVI of the test site was calculated, the results of analysis of MSAVI are displayed in Fig.5. When the results are shown graphically with respect to the data, the relation is seen most clearly. What is evident from the Fig.5 is devoid of vegetation. Dune areas indicated -0.15. However forest areas indicated the high region of 0.4-0.8.

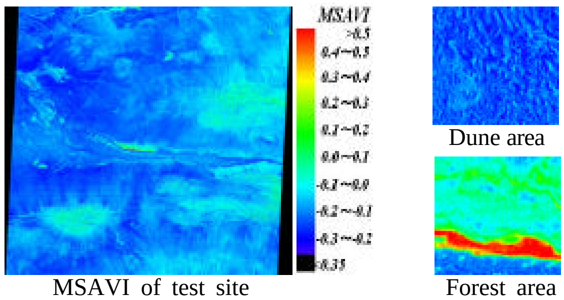


Fig.5 Vegetation level of Gobi desert

3.2 Decision of training area

6 types of ground level were decided by Visual Evaluation Standard(VES). Fig.6 shows this representative example of results. Additionally, the results of MSAVI of training areas are shown in Fig.7. The strongest correlation was observed between method of deciding training area by VES and MSAVI. Herewith, The efficacy of VES was demonstrated.

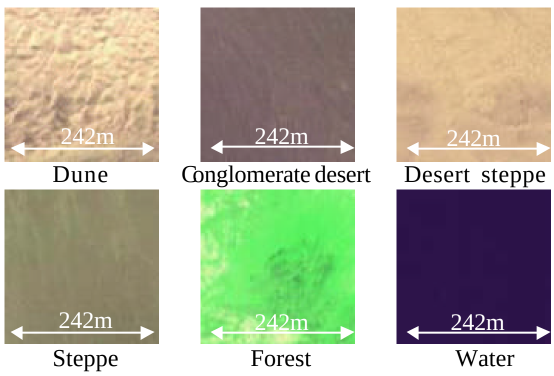


Fig.6 6 types of training areas

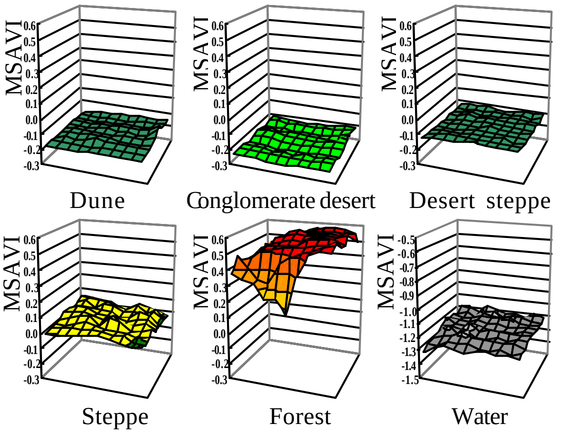


Fig.7 MSAVI of 6 types of ground level

3.3 Gobi desert Classification

Parameters of MLC were set up as reflection level of band1, reflection level of band1+2+3, and MSAVI (table.3). The results of classification based on MLC are displayed in Fig.8. The results were obtained agreed approximately with those expected. Additionally, as these data suggest, it was shown that Gobi desert of ground level is various and turned out that sand dune, a forest, and a water area were very few. From this result, it is able to forecast that PV system installation for right land is very large and have big potential possibilities of electric power generation. Unfortunately, this classification include some problems, for example, the problems lie in misclassification caused by relief shading. Relief shading make a shadow, have a weak reflex. The solution for the problem will be described later. In addition, this algorithm can't adapt to the all satellite images of Gobi desert because the color of these images is unstructured. Sun's altitude causes difference of reflection level, it is difficult to adapt same algorithm. The following point, it is necessary to consider effects of sun's altitude.

Table 3. Parameters of MLC

	Parameter 1 band1	Parameter 2 band1+2+3	Parameter 3 MSAVI
Dune	150.6	559.5	-0.165
Conglomerate desert	102.0	335.0	-0.207
Desert steppe	124.8	474.7	-0.152
Steppe	96.1	339.8	-0.014
Forest	141.1	532.4	0.260
Water	75.1	141.6	-1.216

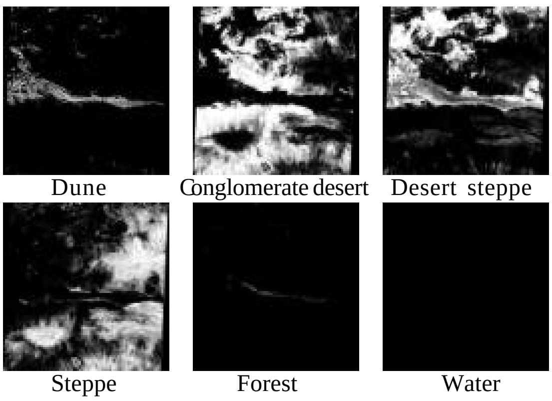


Fig.8 The results of Gobi desert Classification

3.4 Edge lines extraction

Edge lines of mountain, river, and undulating plains were extracted with the use of Laplacian filter for band3. In addition, the processed image was divided into white and black color by threshold level. Threshold level is decided by number of pixels from either end of histogram for processed images. Authors set the number of pixels at 20 percent of the all number of pixels. The area shown white as in Fig.9 exist edge, and the area shown black don't exist edge. Secondly, the image was painted the circumference of the neighborhood where the edge line was extracted all white. Fig.9 shows these results. Herewith, these methods were useful in solving above misclassification problem that was caused by relief shading. However, several problems arise along with these methods. Process of dilatation paints the circumference of the neighborhood where the edge line is extracted, but enlarges noise together. Process of constriction reduces noise, but reduces important information of ground level. This algorithm depends in good part on ground resolution, and authors estimate that the more ground resolution is higher, the more fine edge line can be extracted. The ground resolution that authors applied is approximately 24.2m. As before, surface feature as a boom hoisting and a construction smaller than it can't been recognized. If this algorithm is applied to higher resolution images, it is considered that appreciation accuracy of ups and downs is improved dramatically. These generalizations must be evaluated with caution, lengthy and careful consider should be given to these countermeasures.

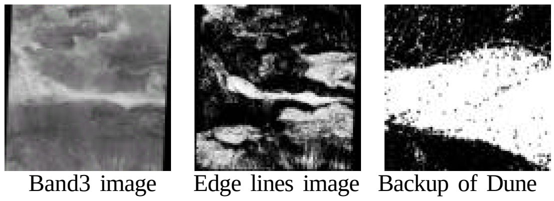


Fig.9 The results of edge lines extraction

3.5 Informational integration

Estimation of the PV system installation for right land was extrapolated by consolidating three Processed images into one as in Fig. 10. These three images are a image extracted as Conglomerate desert, a image extracted as Desert steppe, and a image as edge lines. White areas as in Fig. 11 show the PV system installation for right land. In the next breath, Green areas as in Fig.12 show the right land. Green areas are shown by extracting areas expected to be devoid of vegetation and extracting edge lines. With these methods, the PV system installation for right land can be estimated. In addition, the area percentage for right land was 51 percent. From these percentages, it is considered that the potential possibilities of electric power generation is huge. The detail classification algorithm is displayed in Fig.13.

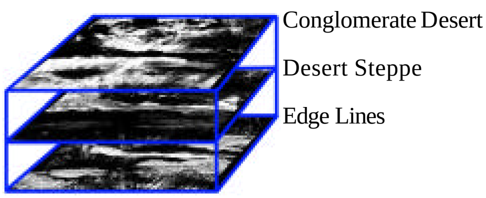


Fig.10 Integration of the three processed images

Fig.11 Monochrome display of the PV system installation for right land

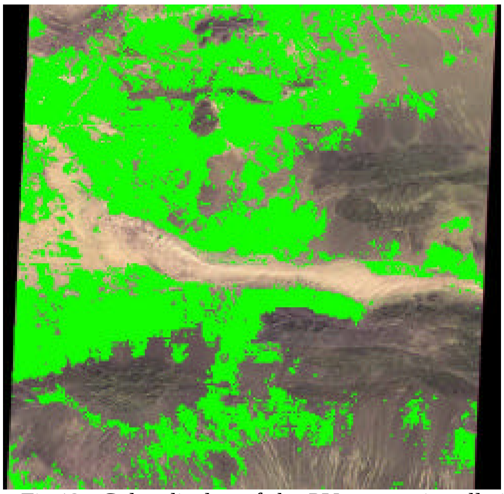


Fig.12 Color display of the PV system installation for right land (Green Color)

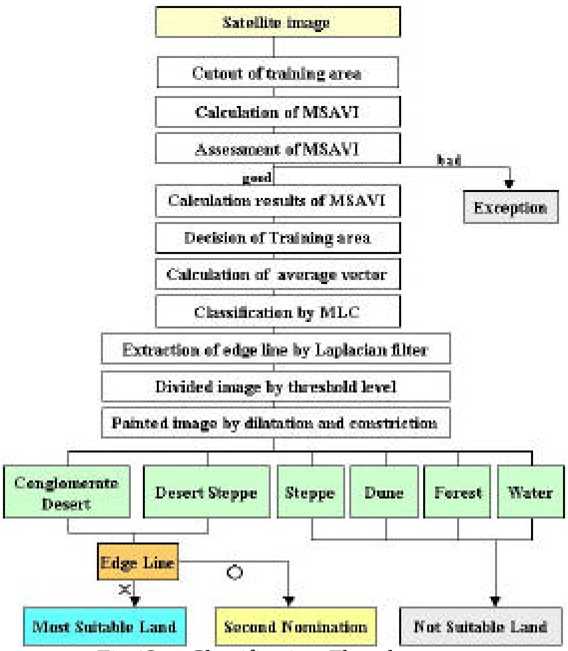


Fig.13 Classification Flowchart

4. CONCLUSION

This study has explored the PV system installation for right land. To summarize our interpretation of the results, we can indicate that the detail classification algorithm for right land is developed. From the afore mentioned point of view, although small portion of Gobi desert, the classification algorithm for suitable land was developed and the right land was estimated. However, the following points are left as future problems. Firstly, one difficulty with this method is in selection of the training area. Ambiguity will be produced because training area is selected by VES. Secondly, dstinction error of ground level will be produced because the difference in the concentration of a image arises by date of satellite images. It is necessary to continue developing the algorithm of estimation of the PV system installation for suitable land. The investigation on estimation of Gobi desert is summarized above and it is evident that more work using different approaches is necessary. At the end, the author would like to express his sincere gratitude to Mr. Amar, who provided related data.

ACKNOWLEGEMENT

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