A Resource Analysis on Solar Photovoltaic Generation System on the Gobi Desert by a Remote Sensing Approach

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Abstract - A project of very large-scale photovoltaic generation system(VLS-PV system) in a desert has been studied in order to resolve the energy problems. This has defined conditions for suitable land for installing large-scale PV. Basic requirements for the land selection are considered that surface should be flat and rigid as well as not moving like sand dune. Gobi desert has researched as the object of this study by using remote sensing. We could indicate that a detail classification algorithm to find suitable land. It is concluded that this proposed method can provide sufficient information for the planning of PV system installations. Additionally, a resource of solar photovoltaic generation in the Gobi desert have evaluated about all of Gobi desert.

Key Words: Photovoltaic power generation system, Remote sensing, Satellite image, Gobi desert

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, photovoltaic generation systems (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. Irradiation in a desert is very strong, it is a suitable land area for large-scale PV system. 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 arid 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 VLS-PV system. Authors demonstrated an efficacy of technique for investigating the suitable area of PV system installations by using remote sensing. Additionally, a potential of solar photovoltaic generation system in the Gobi desert have evaluated about all of the Gobi desert.

2. Materials and Method

2.1 Subject Area and Remote Sensing

Subject area for this study has located in the Gobi desert. Gobi desert is very vast. In addition, 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. 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
	band 2 0.63 to 0.69
	band 3 0.76 to 0.86
Ground Resolution	18.3m 24.2m
Swath Width	75 km

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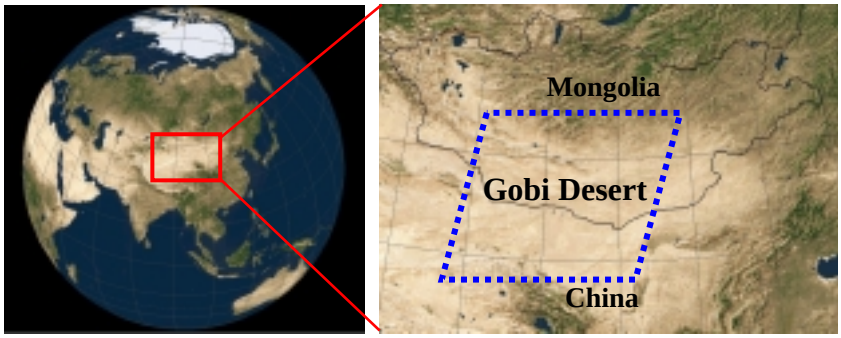
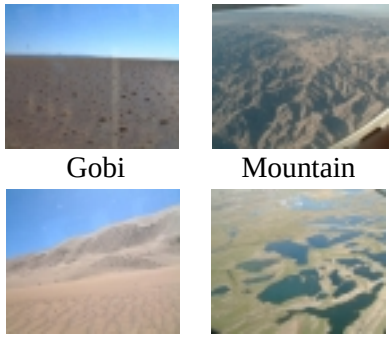


Illustration of the Earth Enlarged illustration of the Gobi desert

Fig.1 Subject area for research



Gobi Mountain Dune River basin

Fig.2 Land surface of Gobi desert

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].

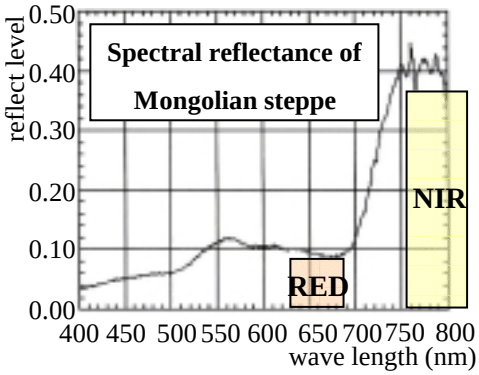


Fig.3 Spectral reflectance of Mongolian steppe

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

We list the necessary care to be taken and problems encountered on applying MSAVI. The problems lie in variation in MSAVI by the difference in date of satellite images. In order to correct the defect, authors estimated a season variation of MSAVI. Season variation of MSAVI was estimated by consideration of three images which are same area but difference in date.

2.3 Classification of the Gobi Desert

Secondly, authors classified the surface of Gobi desert into six patterns from satellite image according to Visual Evaluation Standard (VES) 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 shown below.

1 : conglomerate desert 4 : forest
2 : dune or desert steppe 5 : snow or cloud
3 : desert steppe or steppe 6 : a water or shadow

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

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

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 were decided to be band1/band2, band2/3 and band1/3.

2.4 Filtering of Satellite Image

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 and morphology filter. Edge lines indicate mountains and undulating plain from satellite images. These undulating plains were extracted with the use of these filters.

2.5 Integration of analysis images

Finally, authors integrated three processed images into one image and estimated suitable area for PV system installations. Integration of analysis images provides sufficient information for the planning of PV system installations.

3. Results and Discussion

3.1 Result of Vegetation Index

Authors estimated a season variation of MSAVI. Season variation of MSAVI was estimated by three images which are same area but difference in date. The results of estimation among these images are depicted in Fig.4 and Fig.5. Because only three sample data are existed, all year variation in MSAVI as basic data is quoted from Mei et al. With these parameters, authors created three pattern images by threshold lines as in Fig.5. This suggests that the images shown as suitable area were created for three patterns.

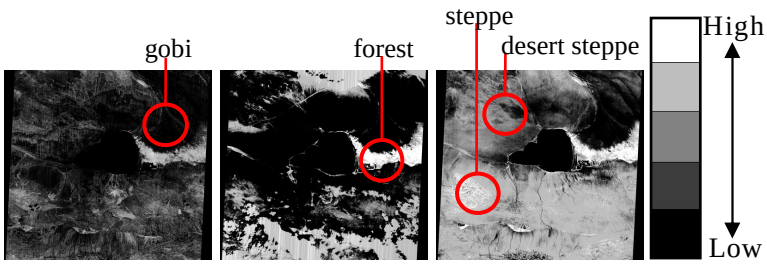


Fig.4. season variation of MSAVI

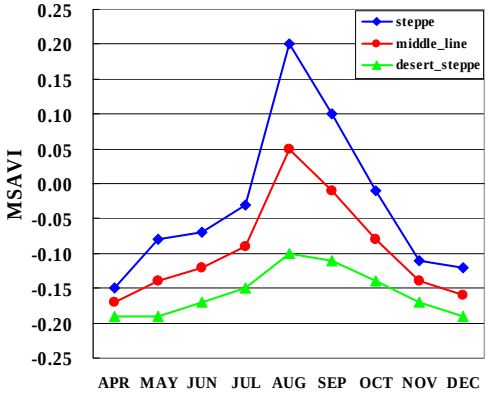


Fig.5 Season variation of MSAVI

3.2 Gobi Desert classification

Parameters of MLC were set up as reflection level of band1/band2, reflection level of band2/3, reflection level of band1/3 (table.2). The Gobi desert classification by MLC played an importable role in excepting areas that is water basin, cloud, snow, shade. This classification provided an available area to analyze.

Table 2. Parameters of MLC

	band1/band2	band2/band3	band1/band3
dune_or_desertsteppe	0.78	1.12	0.87
gobi	0.82	1.26	1.04
desertsteppe_or_steppe	0.74	1.03	0.76
forest	0.90	0.65	0.57
snow_or_cloud	1.00	1.00	1.00
shadow	1.02	1.40	1.43
water	1.43	2.45	3.54

3.3 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 and morphology filter. Morphology filter includes dilation and erosion. Threshold level is decided by number of pixels from either end of histogram for processed images. Authors set the number of pixels at 10 percent of the all number of pixels. The area shown white as in Fig.6 exist edge, and the area shown black indicate flat areas. 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.

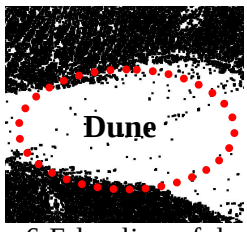


Fig.6 Edge line of dune

3.4 A Resource Evaluation of PV System Potential on the Gobi Desert

Estimation of the PV system installation for suitable land was evaluated by integrating with three processed images, i.e. the image which was presumed as suitable land by MSAVI, the image which was presumed as not suitable land by MLC, and the image which was suitable land by edge lines extraction. Green areas as in Fig.8 show the suitable land of the PV system installation. With these methods, the area percentage for suitable land was estimated at 40 percent. From this result, it is able to forecast that PV system installation for suitable land is very large and have big potential possibilities of electric power generation.

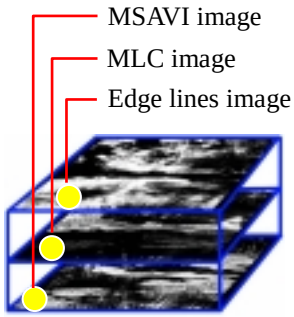


Fig.7 Integration of the three processed images

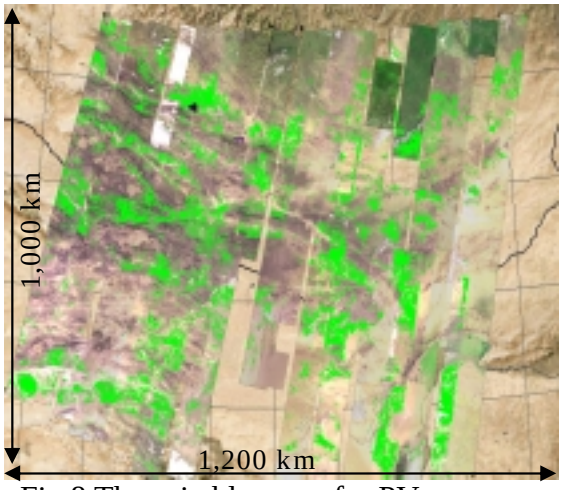


Fig.8 The suitable areas for PV system

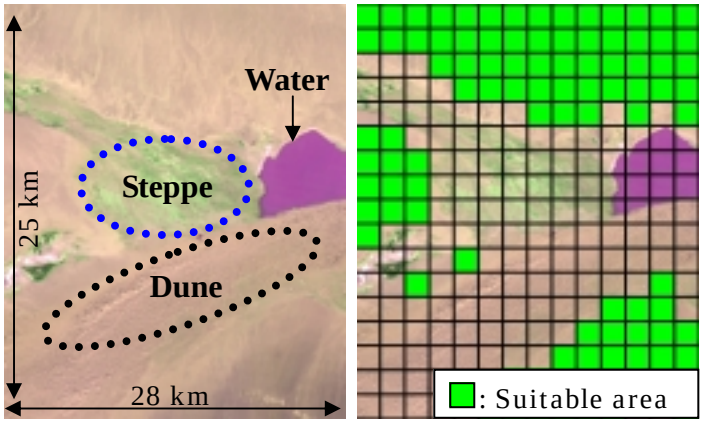


Fig.9 An enlarged example of the Fig.8

4. Conclusion

This study has explored the PV system installation for suitable land. To summarize our interpretation of the results, we can indicate that the detail classification algorithm for right land is developed. From the aforementioned point of view, the classification algorithm for suitable land was developed and the right land was estimated about all area of Gobi desert,. 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, distinction 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. Especially, It is considered necessary to compare analysis result with actual ground truth. At the end, the author would like to express his sincere gratitude to Mr. Amar, who provided related data.

References

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