GLOBAL CHANGE MONITORING BASED ON ECO-CLIMATE MAP

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Abstract

A World vegetation map has been produced by the authors with use of NOAA GVI (Global Vegetation Index) data. The actual vegetation map shows a disturbed of changed land use map according to human activities in the past.

The authors try to produce a potential vegetation map with use of weather data and other geographic data, which is considered a virgin status of vegetation (called as potential vegetation map) to be generated only from climate and other geographic conditions without disturbances due to human activities.

The difference between the actual and potential vegetation must tell us the impacts of human activities. The subtracted image is called "Eco-climate map" in this study, which can show the grade of human impact.

Key words

Human activities, Potential vegetation, Actual vegetation, Assessment, NOAA Global Vegetation Index

1. World Vegetation Mapping

Global Vegetation weekly cloud free NVI (Normalized Vegetation Index) is given from NOAA GVI data. New vegetation classification (8 vegetation types) based on monthly NVI change pattern has been defined by the authors. Many definition of vegetation types has provided by many scientists. But anyone is not quantitative definition. The authors new definition of vegetation types is shown in Table 1 and Figure 1. For example, tropical forest is defined as NVI change pattern with constantly high NVI (about 0.3) all over year. NVI is calculated by the following equation;

$$NVI = \frac{(Ch.\ 2 - Ch.\ 1)}{(Ch.\ 2 + Ch.\ 1)}$$

Ch. 1 : NOAA AVHRR sensor channel 1 Visible band (0.58 - 0.68micrometers)

Ch. 2 : NOAA AVHRR sensor channel 2 Near infrared band (0.73 - 1.10micrometers)

NVI ranges from 0.1 to 0.6; the higher values are associated the greater are the density and greenness of the vegetation.

From the monthly NOAA GVI change pattern from 1982 to 1989, 1983 and 1984 indicate drought years, 1985, 1986 and 1987, these 3 years are very stable GVI change pattern from Table 2 and Figure2. Therefore the authors decided that it is the most reasonable that the world vegetation map should be provided from 3 stable years (1985, 1986, 1987) average NVI. Minimum distance method was applied to 3 years average NVI and the monthly NVI change patterns shown in Figure 1. The result, world vegetation map is shown in Figure 3. This world vegetation definition is a first world vegetation map. Table 3 shows the classified areas with respect to the five continents and eight vegetation types. Though it is a little difficult to compare with FAO's figures, are shown in Table 3 for forest, grassland and desert. According to the authors' definition, there exist 5.9% tropical forest, 31.1% grassland including agricultural areas, 14.9% semi-desert, 1.1% alpine desert, and 16.1% desert. In total 34.0% forest including tropical, evergreen and deciduous forests, 33.9% grassland including tundra, 32.1% desert including semi-desert and alpine desert are distributed on the current earth. They are just one third each.

2. Eco-climate Map

Eco-climate map is a new technical word which was defined by the authors. In the fields of climatology, agriculture and geography etc., climatological zone (Köppen and walter etc.) and agricultural climatic zone (Shreiber etc.) have been proposed with use of temperature, rain fall, arid index and limitation values of the warmest month and the coldest month etc. Because neither digital data for the these values nor computers were available in the e past, it is not enough to testify these values. Therefore existing zoning methods used to include some errors.

Eco-climate map reflects impact assessment of human activities from the following two vegetation maps.

(1) The vegetation map without human activities (Potential vegetation map)

(2) The vegetation map with human activities (Actual vegetation map)

The actual vegetation map reflects the impact of human activities. The potential vegetation map shows the original vegetation that would be generates from the environment conditions.

In this study, the potential vegetation map has been proposed by authors as follows. This process is shown in Figure 4.

① Temperature condition

As a limit of forest growth, the temperature in the coldest month shall not be less -5 degree.

② Topography condition

In the highland over 3000m, there exists almost no dense forest

③ Arid index

The zoning criteria based on the Martonne's AI (Arid Index) are shown in Table 4. The contour lines of monthly average temperature and monthly average rain fall for 30 years (1951 to 1980) are provided from 1500 observation stations data by Iwasaki and Eguchi etc. The authors generated the grid data from the contour lines by the interpolation process. Through the comparison with present vegetation map, climate map and agricultural map etc. the authors decided the zoning criteria as shown in Table 4.

$$AI = \frac{P}{T + 10}$$

Where P : annual rain fall (mm)

T : the sum of 12 monthly temperature over o degree is divided by 12

④ Special condition

Though the soil information are not applied in this study, now the authors are thinking over the soil information. The land which is degraded from salt has almost no vegetation like Australian desert. Then distribution of salt must be considered.

Figure 5 shows the potential vegetation map based on the above mentioned process. In the process there are some unsuitable results, because the distribution and number of observation stations are not enough. Then the tropical forests, evergreen forests and deciduous forests of the actual vegetation map were shifted to the potential map. After that the impacts of human activities were analyzed from the difference between potential vegetation and actual vegetation. Figure 6 and Table 5 shows by color code as shown in Figure 7. In this study, it is called Eco-climate map.

3. Assessment of Human Activities

Eco-climatologicaly, tropical forest should be 13.4% (present : 5.9%), forest should be 35.94% (present : 28.1%), grassland should be 28.7% (present : 33.9%), semi-desert should be 10.6% (present : 14.9%), desert should be 11.4% (present : 17.2%) all over the world. 42.6% of tropical forest has change to forest, 16.5% to grassland, 1.7% to semi-desert or desert. In Thailand tropical forest has changed to grassland (or agricultural land) due to deforestation. African tropical forest has change to open forest of secondary forest.

41.6% of forest has changed to grass land, 3.9% to semi-desert and 1.3% to desert. In the western America large forest has changed to grassland for the western agriculture development. In a similar way forest has changed to agricultural land in China.

27.2% grassland has changed to semi-desert, and 12.7% to desert. These cases represent desertification. In the Sahel of Africa and Neimenggu province (Gobi desert in Mongolia), grassland has changed to semi-desert and in addition semi-desert has changed to desert.

4. Conclusions

The following conclusions were obtained.

(1) A new definition of vegetation types has been pr oposed by the authors using quantitative NOAA GVI ch ange pattern. The first world vegetation map based o n this quantitative definition has been generated.

(2) The authors have proposed Eco-climate map. The i mpacts of human activities were analyzed from differ ences between potential vegetation and actual vegeta tion. The impacts were seen in the Eco-climate map.

References

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Table 1. Definition of vegetation types

Type	Definition
Tropical forest	Very high NVI all year
Evergreen forest	Very high NVI, lower in winter
Deciduous forest	Very high NVI, peaks during summer
Tundra	Very low NVI during winter but medium high NVI during summer
Grassland	Medium NVI during summer
Semi-desert	Only a low NVI for a short time in summer
Desert	Almost no NVI all year
Alpine desert	No NVI in highlands over 3,000 m

Table 4. Comparison of the zonig method between Martonne and Murai/Honda

Martonne	Murai・Honda
$AI \leqq 5$ Desert	$AI \leqq 5$ Desert
$5 < AI \leqq 10$ Semi-desert	$5 < AI \leqq 10$ Semi-desert
$10 < AI \leqq 30$ Grassland	$10 < AI \leqq 20$ Grassland
$AI > 30$ Forest	$20 < AI \leqq 40$ Forest
	$AI > 40$ Tropical forest (annual average temp. over 24℃)

Table 2. Total biomass, 1983 to 1987

Reg. \ Year	1983	1984	1985	1986	1987
ASIA EUROPE	5131652.86	5038578.46	5663822.56	5721458.16	5861486.14
OCEANIA	1055174.36	923612.16	967183.82	972619.58	1086781.01
NORTH AMERICA	2535941.74	2503999.39	2828712.41	2883946.15	2976248.28
SOUTH AMERICA	3864599.31	3508985.18	4331414.78	4241253.92	4061363.55
AFRICA	3051980.05	2725172.52	3449986.61	3497512.09	3405091.92
TOTAL	15639348.32	14700347.71	17241120.18	17316789.90	17390970.90

Unit: Annual Weighted Average NVI

Table 3. Global vegetation, 1985 to 1987

	Trop. forest	Ever-green	Decidu-ous	Tundra	Grass-land	Semi-desert	Alpine desert	Desert	Total
ASIA EUROPE	1268. 2.30	2314. 4.19	11639. 21.08	3155. 5.71	20151. 36.49	7149. 12.94	1232. 2.23	8319. 15.06	55226.
OCEANIA	349. 4.10	853. 10.03	384. 4.52	0. 0.00	1851. 21.76	4284. 50.36	0. 0.00	785. 9.23	8507.
NORTH AMERICA	480. 1.98	1492. 6.15	6066. 25.01	676. 2.78	9810. 40.45	4147. 17.10	6. 0.03	1576. 6.50	24253.
SOUTH AMERICA	5334. 30.87	5485. 31.75	1727. 9.99	0. 0.00	2625. 15.20	1122. 6.49	279. 1.61	704. 4.08	17274.
AFRICA	550. 1.88	3461. 11.85	4372. 14.97	0. 0.00	7313. 25.04	3274. 11.21	3. 0.01	10231. 35.03	29204.
TOTAL	7981. 5.94	13605. 10.12	24188. 17.99	3831. 2.85	41750. 31.05	19976. 14.86	1520. 1.13	21615. 16.07	134465.
TOTAL	34.0%			33.9%		32.1%			
FAO	31.2%			35.4%		33.4%			
	FOREST			GRASSLAND		DESERT			

Upper: × 1000 Km^2 Lower: %

Table 5. Eco-climate zones

		Potential vegetation					
		Tropical forest	Forest	Grassland	Semi-desert	Desert	Total
P	Tropical forest	49.16	0.00	0.00	0.00	0.00	5.9
r							
e	Forest	42.60	60.13	0.00	0.00	0.00	28.1
s							
e	Grassland	16.51	41.59	48.72	13.57	1.28	33.9
n							
t	Semi-desert	1.31	3.92	27.18	42.58	6.84	14.9
v	Desert	0.37	1.30	12.67	38.90	91.67	17.2
e							
g	Total	100.00	100.00	100.00	100.00	100.00	100.00
.		(13.38)	(35.94)	(28.65)	(10.63)	(11.41)	(100)

Unit: % ( ): % of global potential vegetation

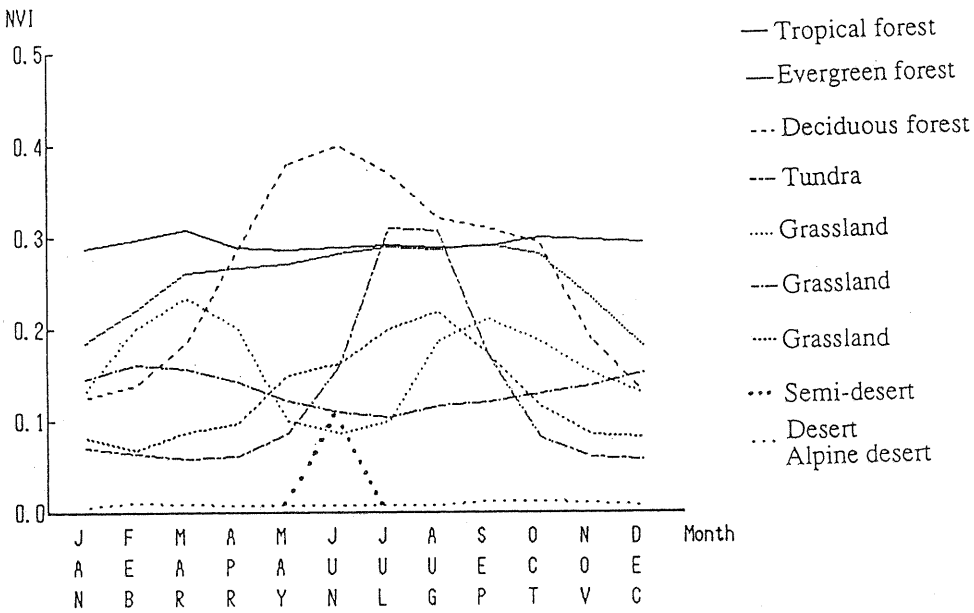

Figure 1. NVI change patterns of vegetation types

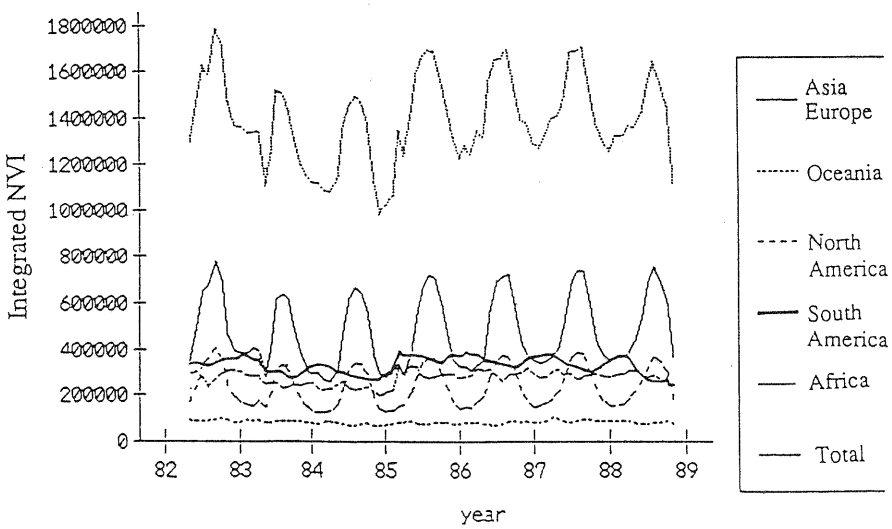

Figure 2. Integrated NVI

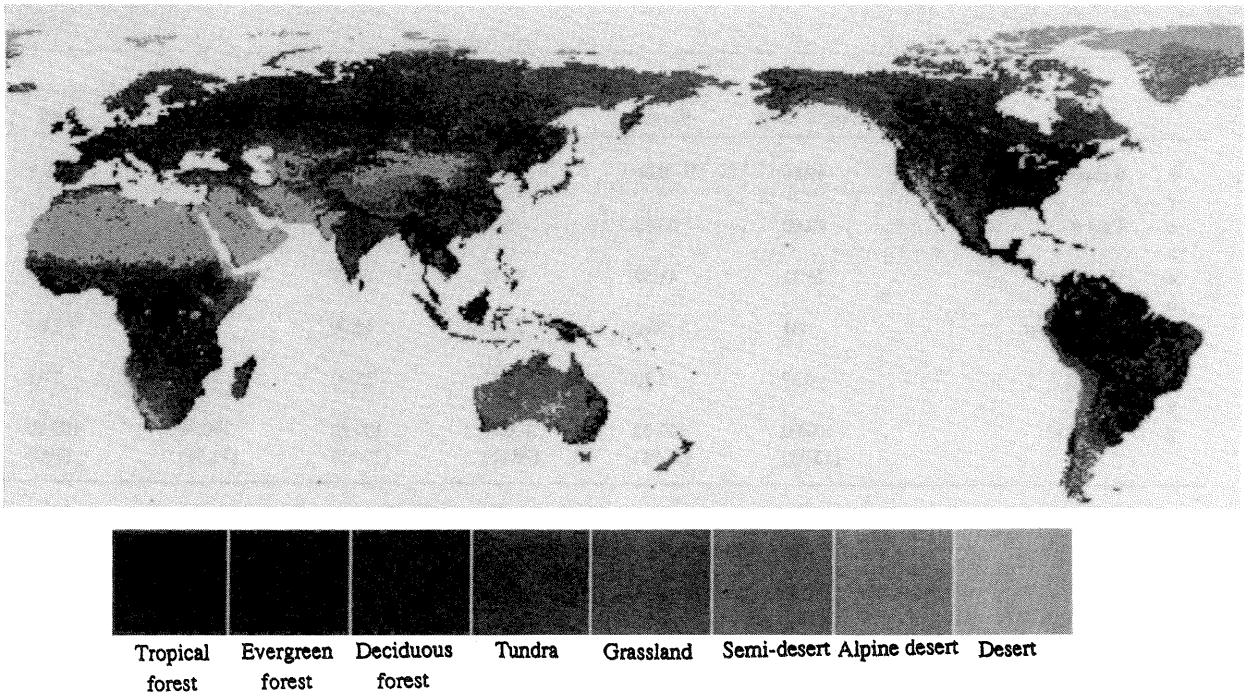

Figure 3. World vegetation map (1985 to 1987)

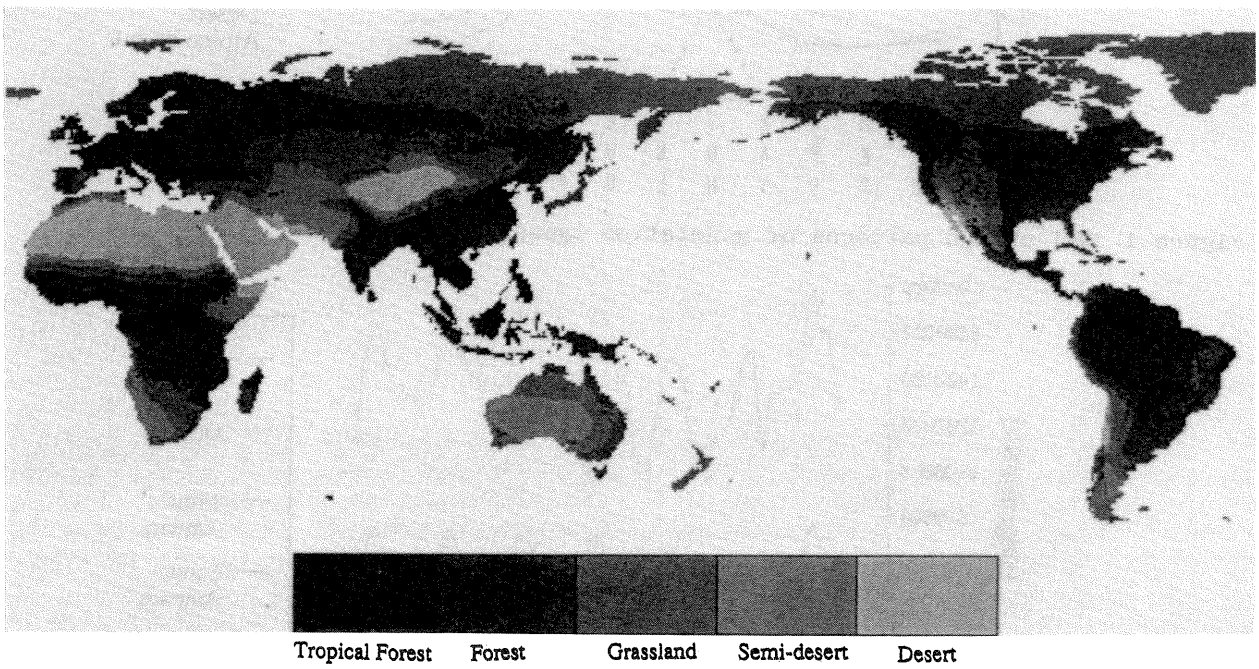

Figure 5. World potential vegetation map

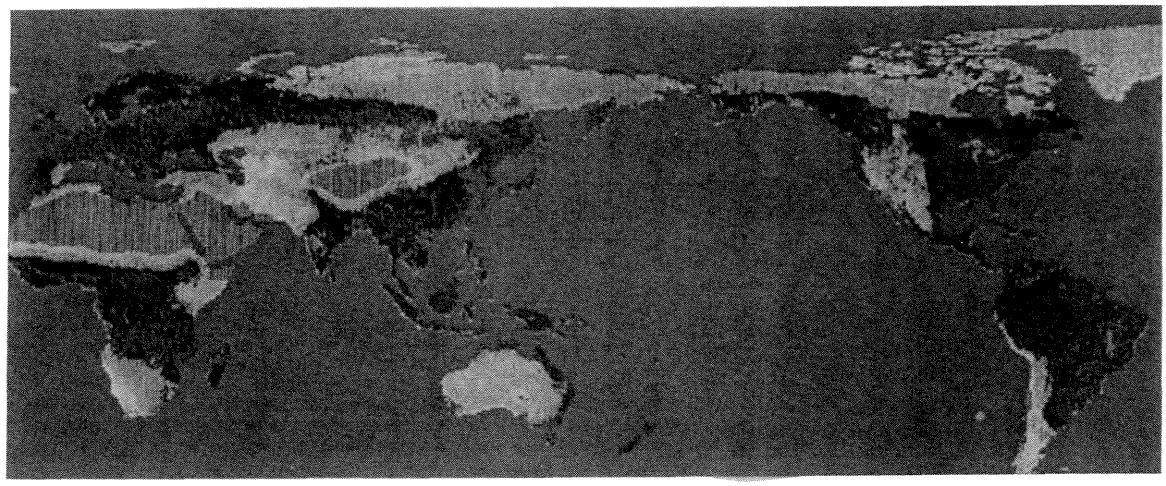

Figure 6. Eco-climate map

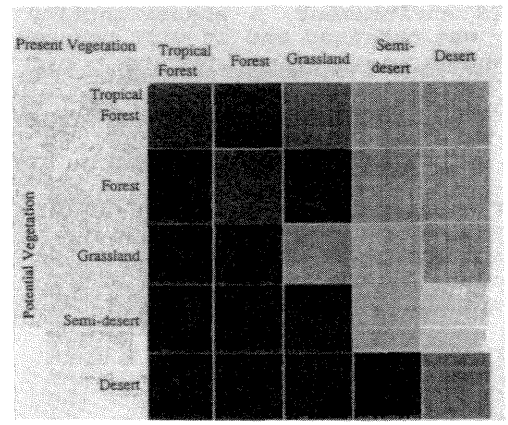

Figure 7. Color code of the Eco-climate map

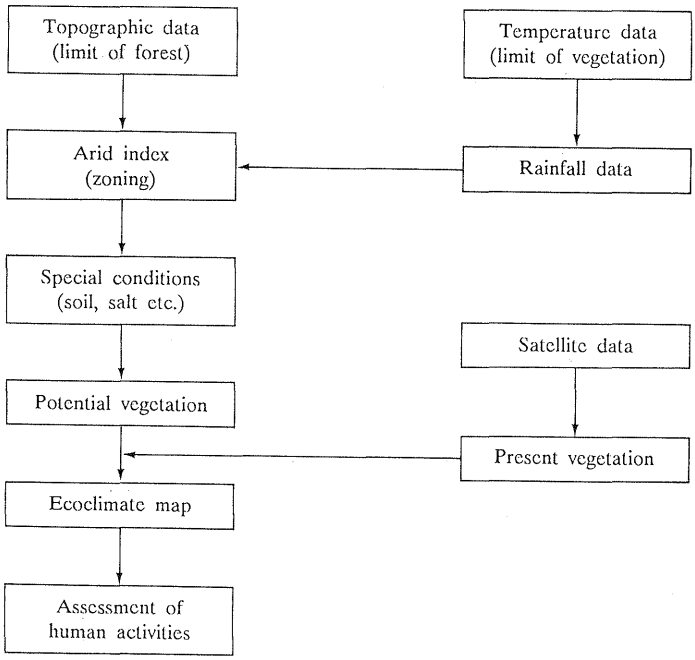

Figure 4. The concept of Eco-climate mapping