Grassland Degradation and Recovery Based on Remote Sensing and GIS in Inner Mongolia

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Abstract

Inner-Mongolia, used to be the fertile field, has been facing the grassland degradation since the past decades. This leads to the less production and impacts the environment of North China. The survey and management based on remote sensing and GIS help the people to recover the grassland and make the development sustainable.

1. Background of the research

Since the 20th century, mankind has been facing many environment problems including the grassland degradation. The grassland degradation causes worldwide environmental concerns, serious impact on the survival of mankind, and also on the environment, society and economy sustainable development. China has the vast territory and grassland area. But these resources have regional disparities, the complex type, grassland vegetation changes within the time and seasons. Human activities deeply affect the grassland with the imbalance between livestock and grassland productivity. Furthermore natural disasters have occurred often. The grassland degradation has become increasing and obvious. Grassland is generally on the recession.

It is clear that some powerful, reasonable and scientifical decisions and actions should be, or must be, taken for reserving and recovering grassland.2. Social and economical development and grassland.

2. Social and economical development and grassland

2.1. Grassland resources and animal products

Compared with some other countries, although the

Table-1-1 Grassland resources of China(2007)

Country	Population (million)	Total area (m.ha)	Grassland(%) -area per person (m.ha/ha)	Agri.land /area per person (m.ha/ha)
China	1276	960	(41.70%)-400/0.31	120 /0.094
Australia	20	769.2	(60%)-458/27	
New Zealand	3.7	26.9	(60%)-16.12/4.36	
Argentina	37.8	2.78	(72%)/200.34/5.3	

Table-1-2 Grassland degradation in China (2003)

Total area (country)	Natural rangeland	Grazing grassland	Degraded grassland	Badly degraded	Agr.land
960 m.ha	400 m.ha	330 m.ha	360 m.ha	180 m.ha	120 m.ha
100%	41.70%				12.50%
	100%		90%	55%	

grassland area per person is not very high, only 0.31 ha, but it is nearly 4 times than the agricultural land which a Chinese has. This ratio of grassland is about 41.70% in the total areas of the country. The whole grassland (400 million ha.) can match Australia's (458 million ha.). (ref. Table-1-1)

This vast grassland distributes in most part, especially the north and the northwest of the country. Inner Mongolia has rich grassland, highest rate of the region. (ref. Figure-2-1)

The Inner Mongolia lies in north China, accounts for about one eighth of the whole country area, across the northeast, north and northwest regions. The natural grass covers the land of 680,000 square kilometers which is an important component of the Euro-Asia grassland band.

2.2. Market requirement and the animal product development

With the fast social and economic development, the requirement for the beef, lamb and milk has been great increase. According to the statistics, only in 7 years (from 2000 to 2006), the production of beef and lamb has been doubled, while the milk production has been nearly 4 times. (ref. Figure-2-2)

2.3. Impact on the grassland and the results

Generally speaking, the grassland of Inner Mongolia has high productivity, 200~1,000kg/ha each year, from west to east. This production could support 0.2~0.5 sheep unit/ha. But, according to the survey, in some places of Inner Mongolia, this number had reached to 10 times or more in several years ago.

It is no doubt that the grassland has to be in recession with the impact of the requirement for the animal products. We have not got any surveying work result to show how the grassland proceeded in the whole areas in the past 30 years. But some alarms, natural disasters, had indicated that the human would face the more fearful environment problem if we wouldn't be thinking about what we should do.

According to the official report that, in north part of China, the sand storms have been more and more often in spring season every year in the past 50 years. There were 5 times every year in 1950's, but 8 times in 1960's, 13 times in 1970's, 14 times in 1980's, and in 1990's, it had reached to 23 times every year. The less and less grass and the other vegetations, the less and less rainfall, the more and more bare land, the sand flows from west to east with strong wind.

Because of grassland degradation, vegetation becomes sparse, the topsoil is exposed, wind diminish the fertility of the land seriously and rapidly. This will not only restrict the development of animal husbandry, but also compact the ecological environment. It is to be understood that, the accurate data should be

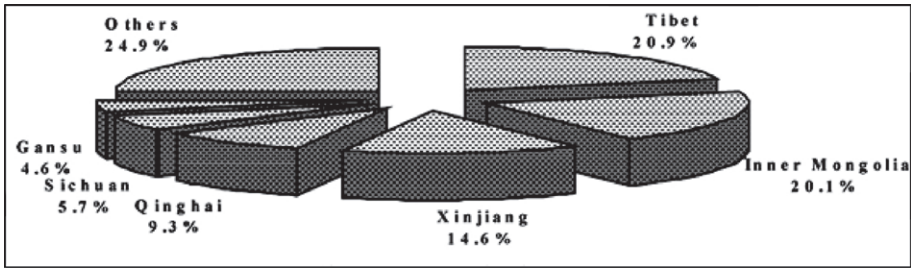

Figure-2-1 Area proportion of China grassland region

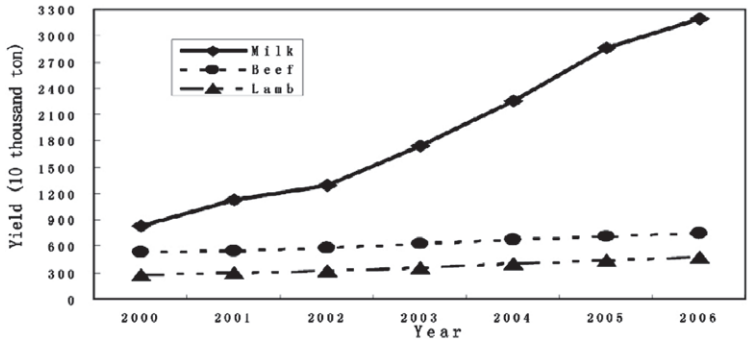

Figure-2-2 China Beef, Lamb and Milk Production

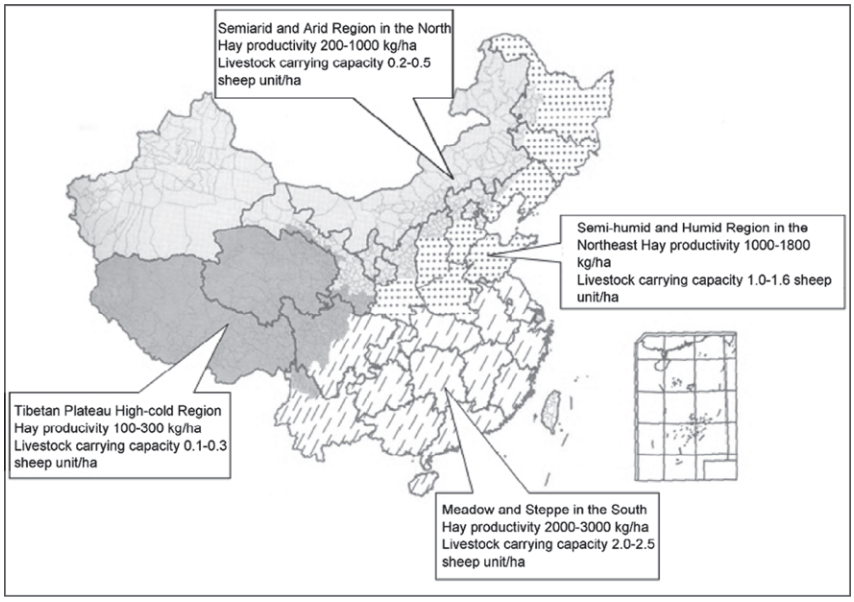

Figure-2-3 Carrying Capacity of different grassland in China

Figure-2-4 Sand Storm in north of China in past 50 years

collected based on the remote sensing and GIS. The degradation evaluation should be taken as a reference to the standards, so that we can understand the status of grassland resources and its development trends. In this case, socio-economic impact on the grassland can be analyzed. Then the grassland can be used reasonably and sustainably based on the good planning and management.

3. The grass growth status survey based on MODIS

3.1. The contents of study and aims

For the degradation survey, the most important is to investigate the biomass and biomass changes of the grass and the other vegetations based on MODIS in short term and long term. Supported by the MODOL, biomass production could be surveyed based on the remote sensing data reflectance, NDVI. With the time, the grass growth statues could be surveyed. The remote sensing system could help to finish this work in real time.

3.2. NDVI and method

EOS-MODIS is a powerful remote sensing system with 36 bands in the electric wave-length, 0.4~14μm, middle spacial resolution 250m~1,000m.

From Figure-3-1 we can see the advanced 7 bands of MODIS. Band-1, red, from 620~670nm; and Band-2, NIR from 841~867nm. From the spectrum characteristic curve, the difference between Band-2 and Band-1 strongly related to the biomass-vegetation growth status. The NDVI value could be calculated according to the following function:

NDVI = (ρNIR-ρR) / (ρNIR+ρR),

in which ρNIR is the reflectance of Band-2(near infrared) and ρR is the reflectance of Band 1(red).

The value range of NDVI is: -1<=NDVI<=1. Negative value is related to the cloud, water or snow. The positive value is strongly related (linear in some ranges) to the vegetation, its coverage and biomass. It means that we could get the biomass from the NDVI in pixel (match to the area on the ground) based on the "MODEL". Although this relationship is sometimes affected by soil background and atmosphere, but anyway, NDVI and EVI (enhancement vegetation index, just like NDVI but joint with atmosphere factor and soil background factor) can indicate the biomass in vast areas.

3.3. The model of sur vey

3.3.1. The flow chart of data processing

In the working flow chart, the core is the MODEL which related to NDVI value in certain pixel, to the relevant truth data of grass on the field as well (the biomass weight in unit, the grass coverage), and the other factors to evaluate the grassland and degradation (the soil moisture, etc.). The classified NDVI value map is very important to let some areas of NDVI value match to some grass production level in one unit.

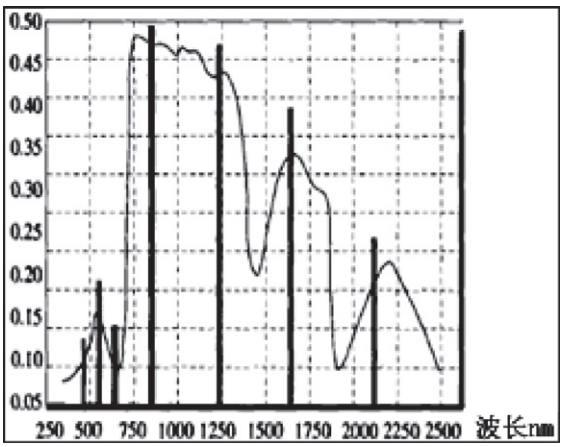

Figure-3-1 MODIS Band 1~7

3.3.2. The mapping of NDVI class

The experimental site located in Xilingole district of Inner Mongolia, the position is from E115°13′ ~117°06′, and N43°02′~44°52′, is a very typical grassland which is bigger than Switzerland in area. Since the NDVI value is about 0.3~0.47, it is divided into 5 different levels: <0.3, 0.3~0.4, 0.4~0.5, 0.5~0.6, >0.6. (ref. Figure-3-3)

3.3.3. Sampling for the truth ground data

On the field work, some vegetation samples (biomass in one unit) were collected in the areas with different NDVI values.

Based on the sample data accompanied with the other information, NDVI, vegetation coverage, biomass and soil moisture, the grassland degradation evaluation method could be used. Different level of the parameters represents the different grassland degradation level: A(less), B(some), C(worse), D(worst).

3.3.4. The SUM of NDVI in seasons of grass growth

The SUM of NDVI in grass growth seasons could more correctly relate to the grass status escaping from some temporal or randomization influence of atmosphere humidity, rainfall, sun shine, etc.

The working steps as follows:

- The MODIS mosaic imagery in ten days without clouds.
- Estimate NDVI for this mosaic imagery.
- Identify the grass growth seasons: 10th of May~10th of Sept.
- There are totally 12 NDVI maps of each 10 days of the grass growth seasons every year.

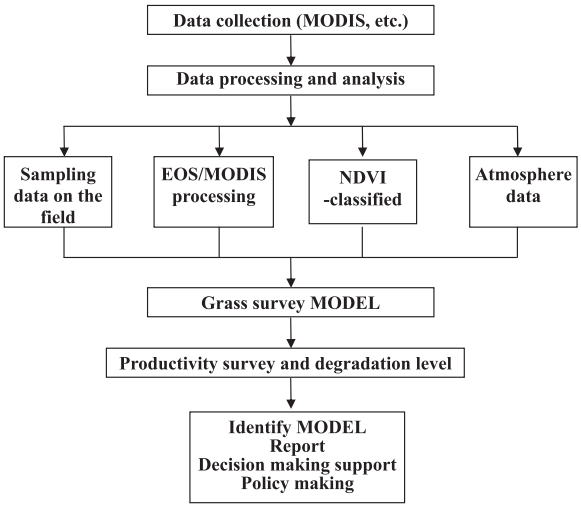

Figure-3-2 Flow chart of working for grass survey based on MODIS

Table-3-1 Grass sample data (2007)

No.	Fresh Mass (g/m^2)	Dry Mass (g/m^2)	Moisture (%)
01	310.00	108.49	71.28
	260.00	82.28	
02	221.00	63.23	68.20
	174.00	86.26	
03	255.00	86.34	71.47
04	205.00	86.34	64.14
05	209.00	82.04	66.47
06	255.00	100.22	65.58
07	160.00	103.63	39.70
08	141.00	95.84	36.72
09	103.00	51.55	61.25
10	74.00	43.40	54.64
11	196.00	83.53	63.19
12	46.00	28.49	62.54
13	95.00	39.88	71.58
14	83.00	40.69	65.09
15	74.00	37.33	65.48
16	84.00	42.12	63.45
17	216.00	83.34	67.00
18	195.00	65.18	73.34
19	74.00	46.79	49.47
20	62.00	39.85	50.34

Table-3-2 Grassland degradation evaluation based on NDVI, etc.

Factor	Grassland Degradation Level			
	A	B	C	D
NDVI	> 0.5	0.4~0.5	0.3~0.4	< 0.3
Coverage (%)	> 50	30~50	10~30	< 10
Biomass (g/m^2)	> 300	300~200	200~100	< 100
Soil moisture (%)	> 3.0	3.0~2.0	2.0~1.0	< 1.0

- SUM 12 NDVI of each 10 days mosaic imagery of every year.
- Establish the survey MODEL
- Study and analyze the results

From the SUM NDVI comparison between 2002 and 2004, it is more clear that the grassland trends to decline in productivity by two years.

3.4. Grassland survey in long term

Based on SUM NDVI some grassland survey could be taken in long term. The grassland changes information is very important in every month, every week in one year. More important thing is that the changes occur on a year by year basis. This long term survey could help the grassland management and environment management.

EOS-MODIS, the powerful remote sensing system for the earth observation, could provide 2 times global data in one day. This program started in 1998, and will be continued till 2013. After that, there will be many other systems. Before 1998, there was NOAA system which was launched in 1960's. The grassland survey in long term will continue in the project.

4. Grassland planning and management based on GIS

4.1. "Grassland Fence" and degraded grassland recovery

Overgrazing is becoming one of the main reasons for grassland degradation. "Grass Fence" could effectively protect the grassland and ecological environment. It is also the most basical, simple and economical way to protect grassland in ecological fragility area and against degradation, and desertification.

After grassland is fenced, the vegetation has a chance to rest and recover. This will give the grassland a good opportunity and fully play to the strong self-repair function of natural grassland. With the times, grassland could recover step by step.

The investigation results have shown that the productivity inside of "Grass Fence" is over two times compared with that of outside at the same landscape position, the same climate and rainfall, the same sunshine, etc. (ref. Table-4-1) It is indeed that the Fence had helped the grass to recover and there is better grass inside of Fence.

4.2. Information collection for "Fence" based on remote sensing

Since there is better grass inside of Fence, it is very easy to find the areas of Fenced grassland. Mapping for the grassland Fence information will help grassland planning and management.

From the working results, we have known that, in Xilinhaot, the capital of the district, the Fenced grassland is less than 20% of the total areas.

And also we have known that, the planning of grassland Fence is not good. A lot of fenced grassland area consumed more materials and investment be-

Table-4-1 "Grass Fence" affects the grass productivity

Grassland	Plant species	Fresh weight	Average(5 samples)
Inside fence (Siziwangqi)	5	29g	36.5g
	5	44g	
Outside fence (Siziwangqi)	3	25g	18.5g
	4	12g	
Inside fence (Ejinhuoluoqi)	6	145g	145g

cause of its independence and unconnected with others. In this case, we must think about how to develop the technology and to construct more Fenced grassland. We need a better plan, we should push this work forward. Remote sensing and GIS could contribute a lot to the planning and management work.

5. Discussion

5.1. Technology and policy making

Technology, remote sensing and GIS, give us a good chance to know the details of grassland and the others. The policy making has got a strong support from the technology. The correct and good policy and regulations affect human's activities. Based on the RS and GIS, the grassland could be used reasonably, the grassland degradation could be better and restored.

5.2. Research and applications

The research results are good and satisfactory. We need to put these case studies into the application in a vast area in the future.

5.3. Cooperation

Grassland reservation and environment protection are very important not only for the local people, but also for the others, nationally and internationally. Exchange of ideas and experiences, sharing of the data and technology, joint working and so on will give us more chances to resolve the environmental issues including grassland reservation.

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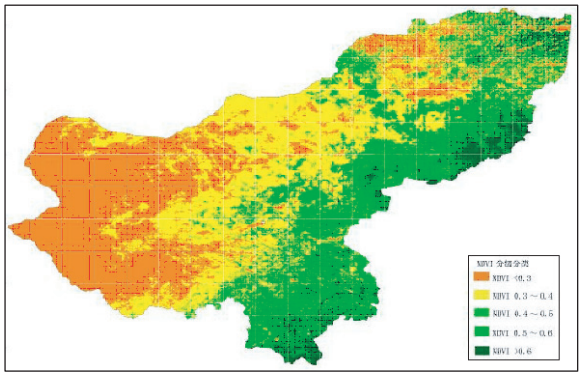

Figure-3-3 Map of NDVI class of Xilingole district, Inner Mongolia

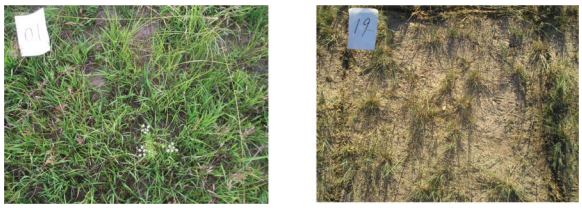

Figure-3-4 Sample No.01 and Sample No.19

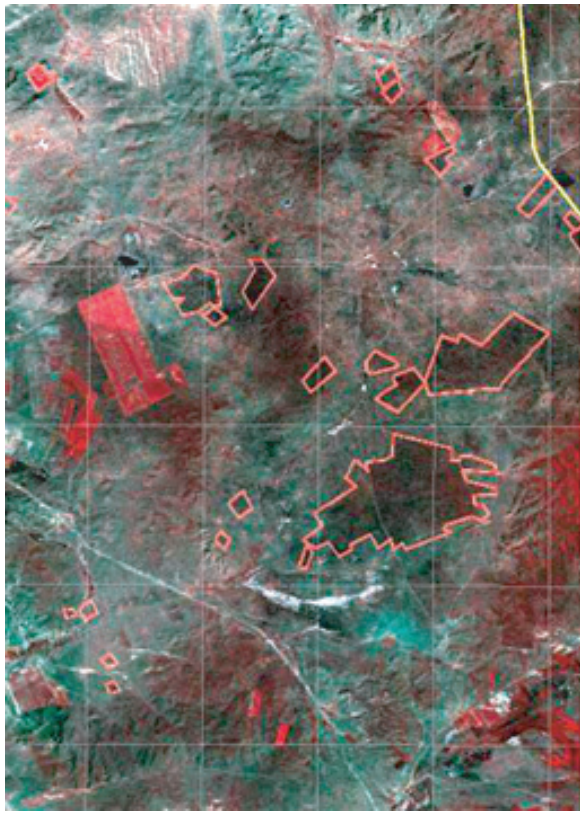

Figure-4-2 Mapping grassland Fence based on ETM

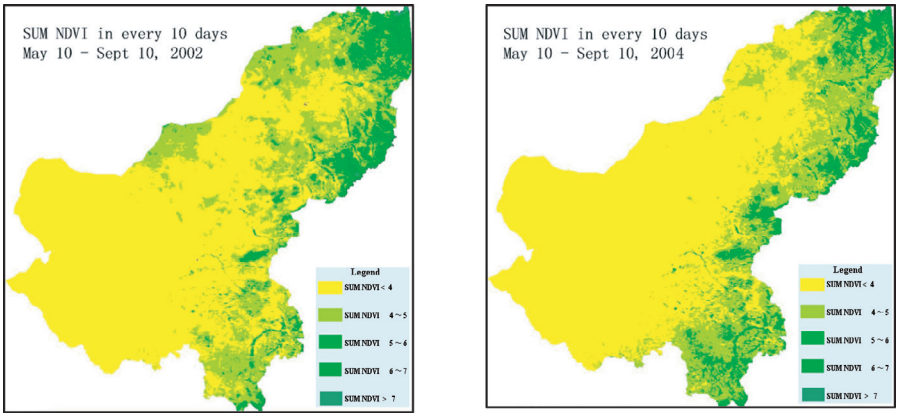

Figure-3-5 SUM NDVI of Xilinguole district 2002-2004

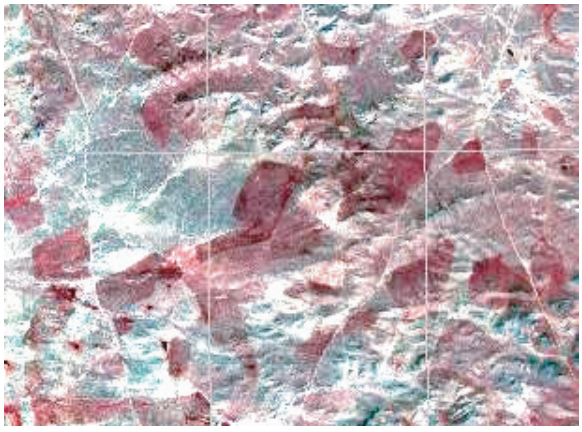

Figure-4-1 The ETM Image in Siziwangqi (the grassland fences)

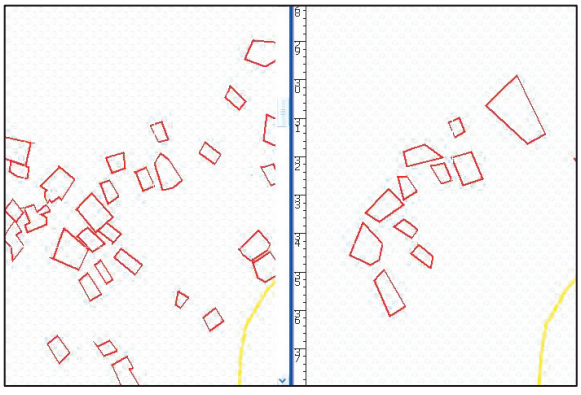

Figure-4-3 Grassland Fence management based on GIS