ESTIMATION AND MAPPING OF PASTURE BIOMASS AND CARRYING CAPACITY USING LANDSAT IMAGERY: A CASE STUDY OF DASHINCHILEN SOUM, BULGAN PROVINCE, MONGOLIA

Munkhnasan.L[1] and Bayartungalag.B*[2], Narangarav.D[3]

[1]Mongolian Academy of Sciences Institute of Geoecology,
Ulaanbaatar, Mongolia; Tel:+976-99065646:
E-mail: naska_l@yahoo.com

[2] NUM-ITC-UNESCO laborator for remote sensing and GIS,
National University of Mongolia, Ulaanbaatar, Mongolia;
E-mail: b_tungalag_b@yahoo.com

[3] NUM- Geography and geology faculty,
National University of Mongolia, Ulaanbaatar, Mongolia;
E-mail: Narangarav Dugarsuren@yahoo.com

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ABSTRACT: In the study used M.Erdenetuya's method. The formula is define vegetation biomass. It formula used by I do Bulgan aimag's Dashinchelen soum of vegetation biomass map. LANDSAT satellite data of 2000, 2004, 2008, 2009 each years was selected to make a vegetation biomass map by Normalized Difference Vegetation Index and Erdenetuya's formula.Then we defined pasture capacity and resource.

I. Introduction

Vegetation biomass estimation for pastureland has received much attention in recent years because the amount of aboveground biomass determines forage availability and thus constrains herbivore carrying capacity (Jobba´gy and Sala, 2000; Yahdjian and Sala, 2006).

In addition to climatic factors there are several human activities especially animal husbandry in the pastureland, is considered as the most essential factors to decrease vegetation biomass. Anticedent two decades, the carrying capacity of pastureland is frequently exceeded in the areas receiving the greatest grazing pressure, affecting on reduction of vegetation productivity due to increasing animal number in Mongolia. Therefore, accurate estimation of biomass is necessary for monitor carrying capacity of pastureland in Dashinchilen soum, Mongolia.

Carrying capacity is the number of animals stocked per acre of grazing land that achieves a targeted level of animal or economic performance over a defined period of time without causing deterioration of the pasture ecosystem.

Harvesting of plant in per unit area (traditional method) is a common method for estimating vegetation biomass study in pastureland, but it has limitations in both temporal scale and spatial extent (Jobba´gy et al., 2002). Nevertheless satellite remote sensing data have been widely used to estimate vegetation biomass or productivity in large area because of a relatively high temporal and spatial resolution. There are a numerous study have been carrying out about vegetation biomass over the whole area of Mongolia. (Oyun & Enkhbayar 1994; Purevdorj 1998; Azzaya 2000; Bolortsetseg 2003; Javzandulam 2004; Erdenetuya 2004).

The main goals of the study are to estimate vegetation biomass and carrying capacity of Dashinchilen soum by using Landsat imagery in 2000, 2004, 2008, 2009.

To achieve this goals, following abjectives will set:

- To estimate vegetation biomass of summer and autumn from the NDVI image derived from Landsat imagery
- To classify vegetation biomass according to its productivity
- To reveal spatial and temporal variation of vegetation biomass
- To examine vegetation biomass and its relationship with aridity index

- To mapping of vegetation biomass
- To monitor pasture carrying capacity based on the vegetation biomass

II. Material and methodology

Materials: We used following materials.

1. Baseline map 1:100000
2. MODIS satellite image of 2000, 2004, 2008, 2009 year’s map
3. LANDSAT satellite image of 2000,2004,2008,2009 years’s map
4. Meteorology data of 2000,2004,2008,2009 year’s that sum
5. Livestock count of 2000,2004,2008,2009 year’s that sum
6. Unified land territory of that sum

Method:

1. **Normalized Difference Vegetation Index**-$NDVI = \frac{Ch2+ch1}{Ch2+ch1}$
2. **Vegetation biomass** - We use following two method.

The method of Purewdorj.D $X=127.48*NDVI-3.087$

The method of Erdenetuya.M $int = \frac{NDVI+128}{0.008}$ $У=0.090*X-11.576$

3. Aridity index

We used method for researcher of Russia Budagovski A.I, Busaravo O.E

$K=P/E_0$, K- Aridity index, P- total precipitation during the period of temperature above 0 °C.

$E_0=a\sum T_{>0,}$ E_0- evapotransiration , $\sum T_{>0}$ - sum of mean daily temperature above 0 °C

4. Pasture capacity, resource

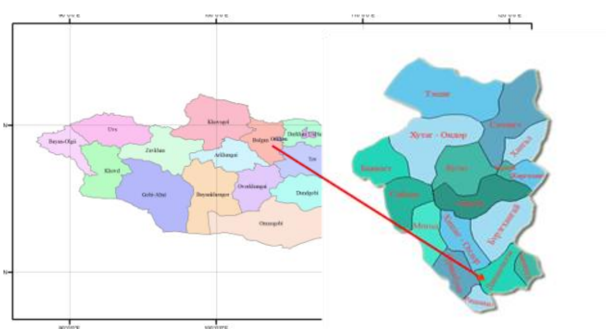
БН=ДУ*Б

БН-Pasture resource, ДУ=runoff in a given year , Б=Pasture

БД=БН/5,6

БД=Pasture capacity, 5,6= stockong rate (year)

III. THE STUDY AREA

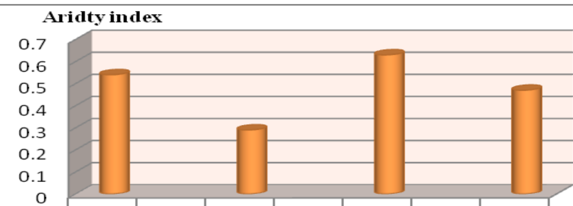


Dashinchilen sum with the territory of total 231896 hectares area exists in south-eastern part of Bulgan province bordering with Bayannuur sum on east side, Buregkhangai on north side, Khishig-Undur and Gurvanbulag sums on north-west side and Rashaant sum on south side respectively. The territory of this sum in respect of the geographic zone involved into the circuit with the low hills and mountains in the basins of Orkhon-Tuul rivers in Khangai-Khentii mountainous zone. In respect of the local relief the earth surface there is planar and the sedimentary deposits in the broad valleys between mountains and hills with river valleys exist at the low levels and regarding to the elevated and hollow earth surfaces pertains to the type of location with little hills and mountains. The average annual air temperature in Dashinchilen sum varies within 1.30-1.90 degrees by Celsius. The coldest annual temperature occurs at the middle period of January when the air temperature becomes equal to -18.9 or -21.4 degrees by Celsius, and the warmest air temperature observed during the middle days of July and then the air temperature reaches to +19.60 or 19.9 degrees by Celsius. The annual average soil temperature there is 5.2 degrees by Celsius and the coldest soil temperature measured during January when the lowest air temperature in Gurvanbulag sum is 20.3 degrees by Celsius and in Dashinchilen sum is -21.4 degrees by Celsius respectively, the absolute low temperature in Dashinchilen sum reaches up to -45.0 degrees by Celsius.

IV. Result

The climate in each ecosystems has different impacts. Thus during the dry arid year with scarce precipitation in the forest steppe zone grows sufficient plant and in steppe zone grows little plant then in desert or desert steppe zones do not grow any plant. And here is very important to find out whether due to the climatic factors or generally over the concerned location prevails the dry climatic state does not grown any plant? This serves by the factor to reveal whether the land area is affected by the depletion of its nutrition substances and deteriorated or not. For this purposes there is possible to apply various methods like getting estimated NDVI for the concerned land area using landsat data of many years with providing interpretation in relation to the climatic factor for the existing there situation and etc. Therefore using MODIS landsat data for 2000, 2004, 2008 and 2009 years regarding to Dashinchilen sum of Bulgan province, which is concerned with as the study area, got calculated NDVI for area of its territory and on diagram No. 2 shown the respective areas of land which were involved for NDVI estimation in the certain years.

The landsat data presents the total amount of green plantation over the concerned area and the highest NDVI value presents the highest capability for growth of plant at a certain land area. In order to learn how NDVI value depends from climatic, especially aridity, factors the drought index for each year is estimated and shown on diagram No. 1.



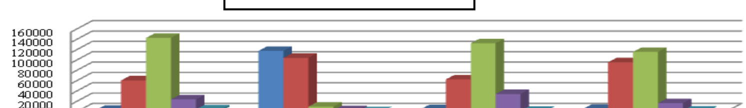
	2000	2004	2008	2009
Aridty index	0.54	0.29	0.63	0.47

Diagram 1Ariduty index

The aridity index over the whole territory of Mongolia varies between 0.05-0.92 and during seasons of plant growth such index in forest steppe region is equal to 0.64, steppe region-0.50, desert steppe region-0.25, desert region 0.14 respectively (Bayasgalan.M, 2005). The proportion of rain (R) precipitation to possible evaporation (PE) index is called as the aridity index (Thohruthwaite, 1960).

Depending from weather condition, air moisture or aridity impact intensities of given year the NDVI value varies and if in arid year with drought the scope of land area with little NDVI value increases then during year with sufficient moisture the scope of area with high NDVI value increases respectively. This relationship could be seen by comparing diagram No. 1 with diagram No. 2.

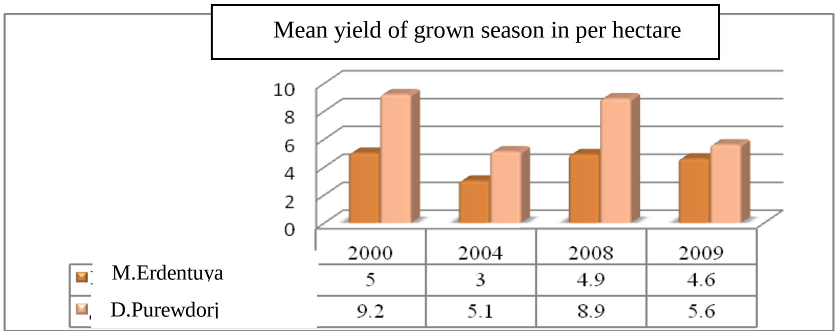
NDVI-squire (ha)



	2000	2004	2008	2009
0.1-0.25	2791	116921	4160	4712
0.25-0.4	59869	103590	61694	94915
0.4-0.55	142180	9097	131629	114961
0.55-0.7	23193	2144	33535	15813
0.7-0.85	3866	147	881	1498

Diagram 2 NDVI-squire (ha)

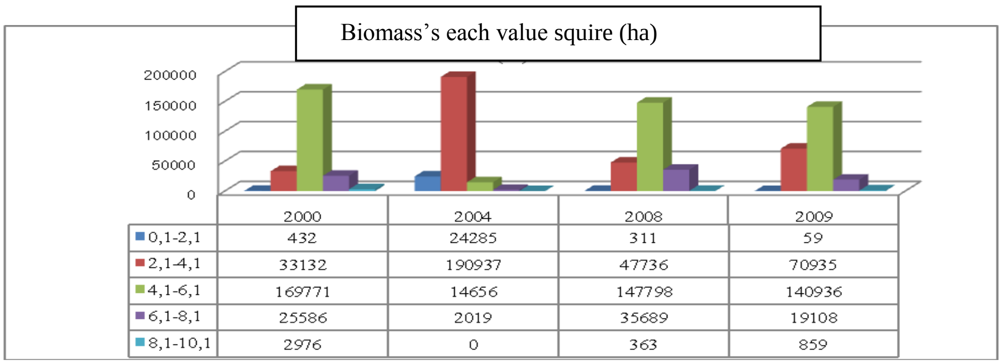
From this graphic could be seen that during the most arid year of 2004 the least NDVI value was prevailing over domineeringly more area of the territory. This presents the fact that NDVI value of a given area depends much from the climatic factors, especially, from aridness. Using estimated NDVI values was been calculated and presented the amounts of plant biomass applying the formula, which was defined by the results of research works conducted by Purevdorj.M, Enkhtuya.M and etc. Using the found out and defined by these researchers formula was been calculated and presented on diagram the plant biomass amounts conforming for each year, which were different, and on diagram No. 3 is presented the amounts of plant biomass estimated to the summer and autumn seasons for each year.



	2000	2004	2008	2009
M.Erdentuya	5	3	4.9	4.6
D.Purewdorj	9.2	5.1	8.9	5.6

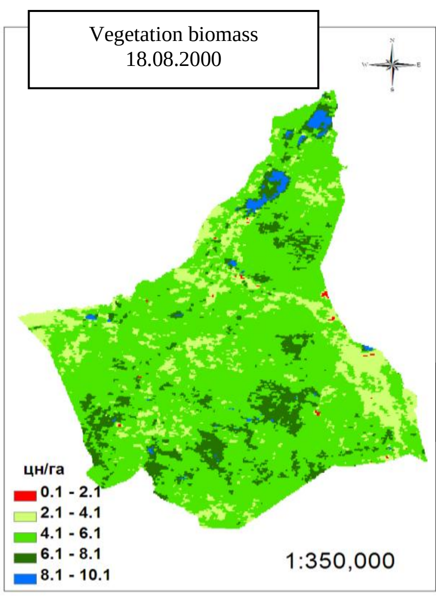
Diagram 3 Mean yield of grown season in per hectare

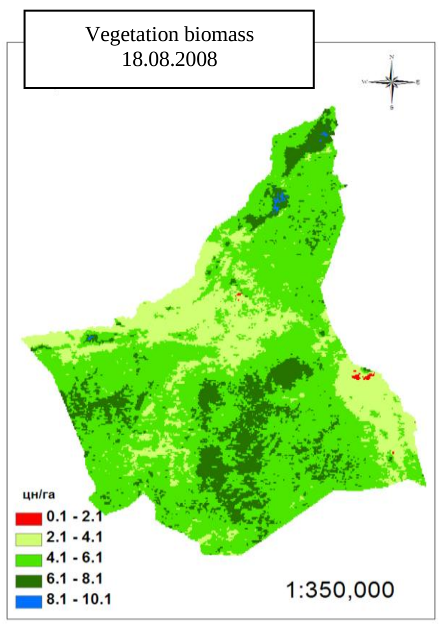
From the above diagram we can see that the value of plant biomass estimated by using the formula defined by Erdenetuya.M is more close to the actual true state and because these values more closely conformed to the results stipulated in the reports of previously done research works the diagram presenting the amounts of plant biomass estimated for each year using that formula is shown below. And due to existing dependence of amounts of the plant biomass from the climatic factors in much arid years the values of plant biomass area much little and the yield of crop collected from a hectare area is poor too. And the stark reverse states are observed in years when fall sufficient rain precipitation creating state with humid air.

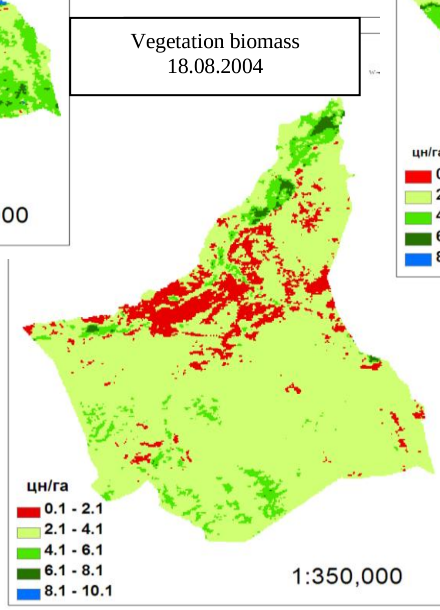


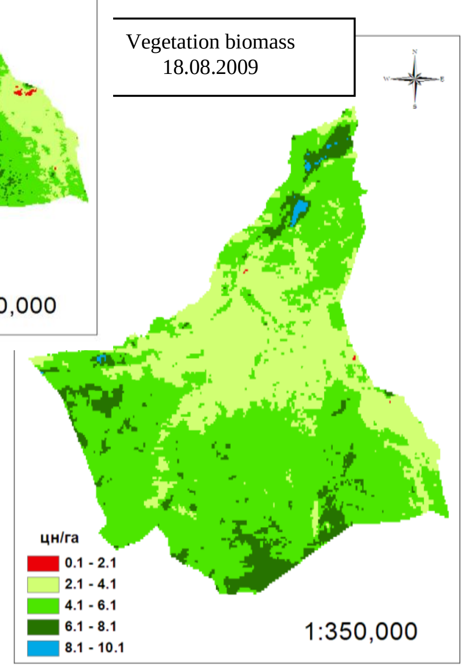
	2000	2004	2008	2009
0,1-2,1	432	24285	311	59
2,1-4,1	33132	190937	47736	70935
4,1-6,1	169771	14656	147798	140936
6,1-8,1	25586	2019	35689	19108
8,1-10,1	2976	0	363	859

Diagram 4 Biomass's each value squire (ha)









Using the plant biomass diagram was defined the pastureland's carrying capacity, its overgrazing intensive exploitation and pastureland reserve over the territory of the sum conforming to each year, which are shown on diagram 4 and table 1 respectively. Into the human activity impact to the natural environment involved the live stock breeding agricultural activities, which due to the overgrazing in the areas of pastureland intensified factors leading to the land deterioration and decreasing its capacity. The pastureland capacity is the indicator presenting ecologic and economic differences presented by the number of livestock heads, which could be grazed over the land area of 1 hectare. The states of overgrazing the pastureland areas exceeding by many times their capacities for duration of consecutive many years deprives growing there plants from their abilities to restore their growths and the locations with sandy soil affected by denudation from plant cover, which in turn creates possibilities to intensive shifting of loose sands. From the results defining the pastureland bearing capacities we can see that the pasture land grazing capacity in 2000 year exceeded by 44.1%, 2008 year by 31.7% and in 2009 by 131% respectively, but even though 2004 year was year with much drought overgrazing on the pastureland was not occurred because the number of grazing then livestock was little. In the areas about the center of sum, pasturelands in valleys of rivers and lakes, locations with water points and wells and near to considerably big sand accumulations the pastureland is greatly deteriorated.

Table 1.

№	Each year	Crop (tn/ha)	Pasture resourse	Pasture capacity (sheep unit)	Total livestock (sheet unit)	Pasture capacity (%)	Overgrazing of pasture (%)
1	2000	5.0	1049723	187451	270130	144.1	44.1
2	2004	3.0	638915	114092	112080	98.14	-1.76
3	2008	4.9	1031661	184226	242640	131.7	31.7
4	2009	4.6	963438	172043	398507	231.6	131.6

According to the results of previously done research works in 2002 year the resource of fodder was 61,95 tons, pastureland grazing capacity 164.2, total number of livestock heads 339.5, pastureland exploitation 206.7%. Even though 2004 year was with much draught the pastureland grazing capacity was not exceeded because in the winter of 2003 year occurred the natural disaster leading to live stock famine and fell many domestic animals and consequently their number drastically decreased.

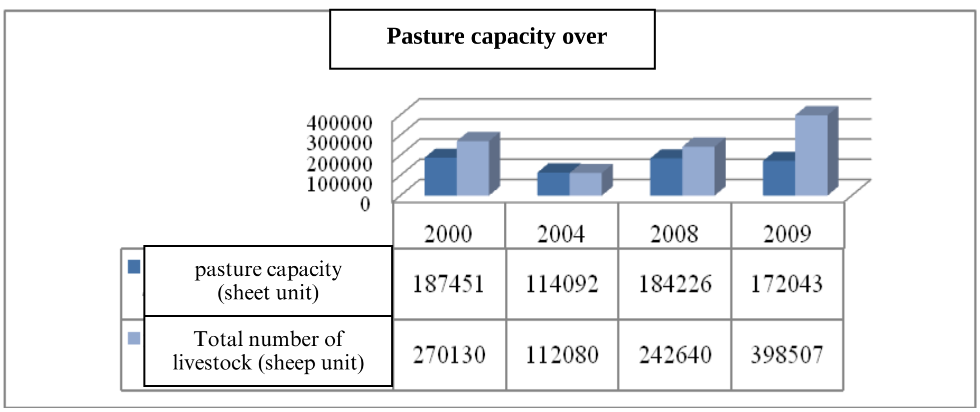


Diagram 5 Overgrazing of pasture

V. Conclusion

Considering above states could be drawn following conclusions:

1. The pasture land grazing capacity in 2000 year was exceeded by 44.1%, 2008 year by 31.7% and in 2009 by 131% respectively.
2. It could be seen that if in conducting the research work use combination of remote reconnaissance method and in-sutu field survey then could be attained to more efficient results.
3. In general the years during which the plant biomass growth was much decreased conforms to years with poor rain precipitation leading to the increased arid state.

In present research work attempted to define the amount of plant biomass using the landsat data and there was established the general principle of experiencing scarce summer during much arid years and good summer during years with much rain precipitation.

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