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ARTICLE

Assessment of Natural Resource Potential of the Landscape of Mongolia (Based on Agricultural Production Resource)

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Abstract: *The landscape contains a variety of different potentials that can perform socio-economic and ecological functions, since landscapes are surface patterns that differ in appearance, environmental components, and their spatial distribution and location. The natural resource potential of the landscape refers to the ability of a landscape to provide society with the raw materials and natural resources, which are required for manufacturing products in the society. The natural resource potential of the landscape can be estimated based on mineral resources, forest resources, agricultural production resources, hunting, and tourism or recreation resources. The purpose of this research was to evaluate the natural resource potential of the landscape based on agricultural production resources. This research was carried out with combined methodology, which involved market price method that was used for assessing agricultural production resources with a GIS-based analytical hierarchy process that was used for developing the potential assessment. The analysis of the spatial distribution map of the natural resource potential of the landscape showed that 41.0 per cent of the area studied had "average" potential, while 34.8 per cent had "low" potential and 19.4 per cent had "high" potential. However, only 2.3 per cent of the area had "very high" potential in terms of potential assessment, whereas, almost the same amount of area (2.5%) was assessed as with "very low" potential. Evaluating the natural resource potential of the landscape, based on agricultural production resources, is important as fundamental information for further research, such as developing a concept of regional economic development and evaluating ecosystem services.*

Keywords: *Natural resource potential; market price method; analytical hierarchy process; agricultural production resource;*

INTRODUCTION

The landscape is part of the earth's surface with a uniform structure and functional pattern [1] in both appearance and components (geo factors: relief, soil, climate, water balance, flora, fauna, humans and their creations in the landscape), including their spatial position [2].

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Thus, landscapes can perform various socio-economic and ecological functions that create natural resources and conditions necessary for human habitat [3] and each of them has its own specific natural potential. The concept "natural potential of the landscape" was formulated by N. A. Solntsev as "... those internal opportunities that are prepared in the landscape by nature itself ..." [4], scientific substantiation, and the first detailed studies about the concept were carried out by the Russian geographer A. G. Isachenko [5, 6, and 7]. According to Isachenko, the natural potential of landthe potential for landscape stability, and natural resource potential [8]. In this study, we tried to assess the natural resource potential from the above three mentioned potentials of the landscape.

"Natural resources potential of landscape" is a concept related to the function of geosystem resources (production) as the ability of the landscape to provide society with the raw materials needed to produce goods and products [5], so it can be estimated based on mineral and raw material, forestry, agricultural, hunting and fishing, recreational resources, etc. [9]. The purpose of this study was to assess the natural resource potential of landscapes in Mongolia based on the agricultural production resource and so, other resources were not considered in this study.

In order to assess the natural resource potential of a landscape, it is first necessary to assess the natural resource through an economic assessment. Economic valuation is a set of methods for expressing the value of a product in monetary terms, which increases or decreases depending on the supply and demand for goods and services [10]. Therefore, economic valuation of natural resources of the landscape is a monetary valuation of goods and services that are created within the environment or natural zones and belts, and are in economic circulation. There are several methods for evaluating natural resources. Each one has its own strengths and weaknesses, and certain methods are most appropriate for specific situations depending on the type of information that is being looked for. There are "revealed preference approaches" and "stated preference approaches" [11]. The revealed preference approaches extrapolate the individual's willingness to pay or except by examining the choices that he or she makes within a market. The revealed preference approaches are market price method, productivity method, hedonic pricing method, travel cost method, substitute cost method, replacement cost method, and damage cost avoidance method. The stated preference approaches of ecosystem valuation survey individuals to find out what they state as their value of the ecosystem attributes, goods and services. The stated preference approaches are contingent valuation, conjoint analysis, and the contingent choice method.

In this study, the market price method in revealed preference approach was used since this method is widely used in economic valuation of agricultural production resources [12, 13, and 14]. The standard method for measuring the use value of resources traded in the marketplace is the estimation of producer surplus using market price method and quantity data [15]. The market price method is a method of estimating the economic value of ecosystem products and services sold and traded in the market [13]. In econometric and socioeconomic research, more detailed research, such as potential assessment, has recently been developed to combine the market price and cost-based methods with a multi-criteria decision making method [16].

In Mongolia, 85 per cent of the local economy is based on agricultural production, and at the end of 2019, the agricultural sector accounted for 10.9 per cent of total GDP [17]. Furthermore, livestock is an important sector of the country's economy, and agricultural exports account for 8.4 per cent of export earnings, and 30 per cent of the total labour force working in this sector [17]. The potential assessment needs to be developed to differentiate which agricultural products are contributing to the development of the Mongolian economy based on production, export rates, and market efficiency of type of crops and livestock produce. Thus, this research was conducted in combination with the market price method and the multi-criteria decision making analysis method.

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MATERIALS AND METHODS

The market price method uses the price of goods and services that are bought and sold in commercial markets to determine the value of natural resources [18]. In this study, the economic value of agricultural produce was evaluated based on the output of agricultural products and current market prices for each agricultural product types. However, the study mainly focused on the concept of "natural resource potential" because it is a potential assessment study. For that reason, the results of the study and the mapping were produced based on economic valuation, and the natural resource potential was performed using an analytical hierarchy process with five evaluation levels, namely very high, high, moderate, low, and very low (Figure 1).

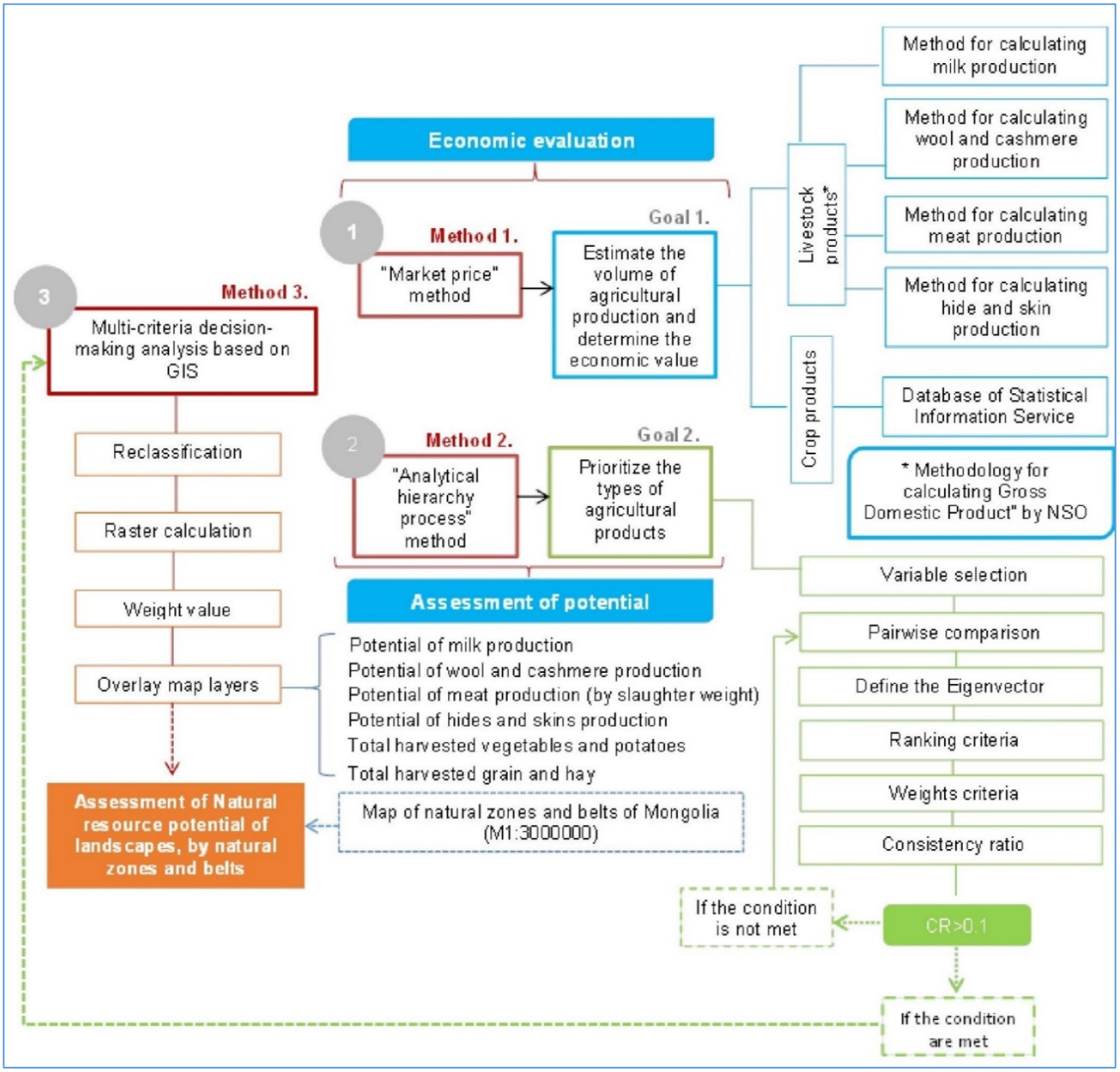

Figure 1. Workflow map for this study

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Method for estimating economic valuation

According to the "Methodology for calculating GDP" (Order 13/134 of the Chairperson of the National Statistics Office - NSO) developed by the NSO, the amount of milk, wool, cashmere, skins, and meat production (by slaughter weight) from livestock products were estimated for each type of livestock, while data on the output of crop products were used from the database of Statistical Information Service. The baseline indicators in the methodology for determining the economic value of agricultural produce, as shown in Table 1, are all indicators for the period 2005-2019.

Table 1. Method for estimating the economic value of livestock products [19]

№	Milk	Wool and cashmere	Meat (slaughter weight)	Hide and skin
Baseline indicators				
1	Number of survival, by type (1)	Number of livestock, by type (1)	Number of livestock at the beginning and end of the year (2), by type	Number of livestock slaughtered for consumption, by type (1)
2	Number of twin young animals (2)	Percent of livestock to receive wool and cashmere (2)	Number of survival (3)	Losses of adult animals (2)
3	Percent of breeding stock in lactation, by type (4)	-	Number of heads of animals died (4)	-
4	Annual average milk yield per animal, by type (6)	Annual average wool yield per animal, by type (4)	Annual average meat yield per animal, by type (7)	Possible percent of hide and skins from losses of adult animals (3)
5	Loss of milk, by type (8)	Loss of wool and cashmere, by type (6)	Number of animals exported (5) and imported (6)	Loss of hide and skin, by type (5)
6	Milk producer price (10)	Wool and cashmere producer price (8)	Meat producer price (8)	Hide and skin producer price (7)
Estimated parameters				
7	Number of dam with suckling, by type (3)=1-2	-	Number of livestock slaughtered for consumption, by type (8)=1+3-4-5+6-2	Number of hide and skin used, by type (4)=(1+(2*3/100))
8	Number of dam in lactation (5)=(3*4)/100	Number of livestock that received wool and cashmere (3)=1*2	-	-
9	Total milk production (7)=(5*6)/1000	Total wool and cashmere production (5)=3*4	-	-
10	Total milk production to be used, tonne (9)=7-8	Total wool and cashmere production to be used, tonne (7)=5-6	Total meat production to be used, tonne (9)=7*8	Total hide and skin production to be used, thous.pieces (6)=4-5
11	Total milk production, mln.togrogs (11)=9*10	Total wool and cashmere production, mln.togrogs (9)=7*8	Total meat production, mln.togrogs (10)=9*8	Total hide and skin production, mln.togrogs (8)=6*7

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Gross crop products, such as grain, potatoes, vegetables, and hay harvest, which have been calculated according to the "Methodology for Calculating Agricultural Sector Statistics" (Annex I to order of the Chairman of the NSO №A/142), was used as a primary material in this study from the database of Statistical Information Service.

Method for estimating potential assessment

It is appropriate to estimate potential based on several evaluation criteria, such as economic efficiency between these types of products after calculating the output of agricultural products produced by each aimag and soum of Mongolia, based on the market price method. For that reason, the natural resource potential of the landscape was developed in accordance with the output of agricultural products, which were calculated by the market price method and the hierarchy of agricultural products, which were ranked according to the analytical hierarchy process.

The Analytical Hierarchy Process (AHP), introduced by Thomas Saaty (1980), is an effective tool for dealing with complex decision making and may aid the decision-maker to set priorities and make the best decision [20]. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision.

Computing the vector of criteria weights. In order to compute the weights for different criteria, the AHP starts creating a "pairwise comparison matrix". Matrix A is a m×m real matrix, where m is the number of evaluation criteria considered. Each entry a_{jk} of the matrix A represents the importance of the j^{th} criterion relative to the k^{th} criterion. If $a_{jk} > 1$, then the j^{th} criterion is more important than the k^{th} criterion, while if $a_{jk} < 1$, then the j^{th} criterion is less important than the k^{th} criterion. If two criteria have the same importance, then the entry a_{jk} is 1. The relative importance between the two criteria is measured according to a numerical scale from 1 to 9, as shown in Table2, and it is also possible to assign intermediate values (2, 4, 6, 8) which do not correspond to a precise interpretation [21].

Table 2. Relative scores [21]

a_{jk}	Interpretation
1	*j* and *k* are equally important
3	*j* is slightly more important than *k*
5	*j* is more important than *k*
7	*j* is strongly more important than *k*
9	*j* is absolutely more important than *k*

Once the matrix A is built, it is possible to derive from A the normalized pairwise comparison matrix A_{norm} by making equal to 1 the sum of the entries on each column, i.e. each entry $\overline{a_{jk}}$ of the matrix A_{norm} is computed as:

$$\overline{a_{jk}} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \quad (1)$$

Finally, the criteria weight vector w (that is an m-dimensional column vector) is built by averaging the entries on each row of A_{norm}, i.e.

$$w_j = \frac{\sum_{l=1}^{m} \overline{a_{jl}}}{m} \quad (2)$$

Checking the consistency. When using the analytical hierarchy process, the consistency ratio is obtained by the following formula:

$$CR = \frac{CI}{RI} \quad (3)$$

Where, CR – consistency ratio, CI – consistency index, RI – Random index

$$CI = \frac{\alpha_{max} - n}{n-1} \quad (4)$$

Where, α_{max} – maximum Eigenvalue, N – Order of the matrix, CI- consistency index

Table 3. Values of the random index (RI) depends on the order of the matrix

N	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

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$$\frac{CI}{RI} < 0.1 \quad (5)$$

A ratio of consistency and random index of 0 assumes that the comparison is completed and if the ratio is less than 0.1, the results can be used in the study and is also acceptable [22].

Selection of evaluation criteria. In order to evaluate the natural resource potential for agricultural products, the following evaluation criteria were selected to identify and rank livestock and crop products by their type.

A total of 7 evaluation criteria, which are milk, wool and cashmere, skin and hide, and meat production from the livestock sector, and, hay, potatoes, vegetables and harvested grains from the agricultural sector, were selected. Since 4 out of the 7 evaluation criteria are related to the livestock sector, there is a need to differentiate between the types of livestock production, so the sub-criteria were also identified and shown in Table4.

Table 4. The evaluation criteria and sub-criteria for evaluation of natural resource potential

Criteria	Type	Sub-Criteria (SC), Consistency Ratio (CR) and literatures used for ranking	Unit	AHP ranking in type
Milk production potential, by type	*c1.* Cow milk	*sc1.* Milk production (CR:0.05) [23]	mln.litre	I
	c2. Goat milk	*sc2.* Milk production per capita (CR:0.06) [17]	litre	II
	c3. Sheep milk	*sc3.* Milk yield (CR:0.17) [17]	litre/year	V
	c4. Mare milk	*sc4.* Duration of lactation (CR:0.07) [24]	month	III
	c5. Camel milk	*sc5.* Percent of milk consumption (CR:0.17)	%	IV
	$x = 49.7c1 + 19.6c2 + 8.8c3 + 11.3c4 + 10.3c5$ *(Consistency ratio: 0.1)*			
Wool and cashmere production potential, by type	*c1.* Cattle wool	*sc1.* Wool and cashmere production (CR:0.14) [23]	thous.tonne	IV
	c2. Goat cashmere	*sc2.* Wool production per capita (CR:0.08) [17]	tonne/year	III
	c3. Sheep wool	*sc3.* Wool and cashmere yield (CR:0.06) [24]	grams/year	I
	c4. Horse wool	*sc4.* Manufacturing percent (CR:0.05) [23]	%	V
	c5. Camel wool	*sc5.* Rate of export (CR:0.04)	thous.tonne	II
	$x = 6.58c1 + 18.78c2 + 44.1c3 + 5.02c4 + 25.52c5$ *(Consistency ratio: 0.08)*			
Meat production potential, by type	*c1.* Beef	*sc1.* Meat production (CR:0.08) [23]	thous.tonne	II
	c2. Goat meat	*sc2.* Meat production per capita (CR:0.07) [17]	kg	V
	c3. Mutton	*sc3.* Meat yield (CR:0.06) [19]	kg	I
	c4. Horse meat	*sc4.* Manufacturing (CR:0.03) [25]	tonne	III
	c5. Camel meat	*sc5.* Rate of export (CR:0.12)	thous.tonne	IV
	$x = 24.72c1 + 11.9c2 + 29.0c3 + 21.72c4 + 12.68c5$ *(Consistency ratio: 0.07)*			
Skin production potential, by type	*c1.* Cowhide	*sc1.* Hide and skin production (CR:0.14) [23]	thous.pieces	I
	c2. Goatskin	*sc2.* Skin production per capita (CR:0.05) [17]	pieces	III
	c3. Sheepskin	*sc3.* Manufacturing (CR:0.11) [24]	tonne	II
	c4. Horsehide			IV
	c5. Camel hide			V
	$x = 34.8c1 + 22.03c2 + 29.6c3 + 9.5c4 + 4c5$ *(Consistency ratio: 0.1)*			
Grain	There is no need to classify crop products by type.	There is no need to classify crop products by sub-criteria.	tonne	No need to specify
Potatoes			tonne	
Vegetables			tonne	

To draw a map of the natural resource potential (based on agricultural production resource) of landscape, a thematic layers of 7 evaluation criteria, including milk production, wool and cashmere production, meat n and skin production, and crop production were created, and those evaluation criteria were ranked according to their importance based on our own and other countries' practices, literature and expert knowledge (Table5). After weighing the importance of different criteria for natural resource potential, all thematic layers were overlaid using the following equation:

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Table 5. Defined ranking and weights of the criteria for evaluating natural resource potential

№	Criterion	Weight	Ranking
1	Wool and cashmere production potential (W)	0.411	I
2	Milk production potential (M)	0.231	II
3	Sown area of grain (C)	0.148	III
4	Meat (slaughter weight) production potential (F)	0.1	IV
5	Total harvested potatoes (P)	0.054	V
6	Total harvested vegetables (V)	0.031	VI
7	Hide and skin production potential (H)	0.025	VII

$$\mathbf{AP = W * 0.411 + M * 0.231 + C * 0.148 + F * 0.1 + P * 0.054 + V * 0.031 + H * 0.025}$$

Based on the defined ranking and weights of the evaluation criteria, which were identified during the analytical hierarchy process, all thematic layers were overlaid, and "Assessment of natural resource potential of Mongolia (based on agricultural production resource)" map with 1:8500000 scale was developed.

RESULTS AND DISCUSSION

Assessment of milk production potential

According to the research results, an average of 519.9 million litres of milk can be produced annually (2005-2017 average) from agriculture, of which 55.9 per cent or 291.02 million litres of milk is produced from cattle farms and 21.0 per cent or 109.25 million litres from goat farms. Also, camel milk accounts for 4 per cent and mare's milk 8 per cent of total milk production. Aimags in the Khangai region account for 39.5 per cent of the cow's milk, 44.1 per cent of mare's milk, 36 per cent of sheep and goat milk, and about 32 per cent of camel's milk of total milk production potential from agriculture.

Considering the total milk production in the country on an average in million litres, Undur-Ulaan, Chuluut, Ikh-Tamir, and Erdenemandal soums of Arkhangai aimag lead with an average annual potential of 4.0-4.9 million litres of milk from agriculture. In addition, Uyanga soum of Uvurkhangai aimag, Umnudelger soum of Khentii aimag, Erdenetsogt soum of Bayankhongor aimag, Battsengel soum of Arkhangai aimag and Mandal soum of Selenge aimag produce more than 3.5 million litres of milk in one year.

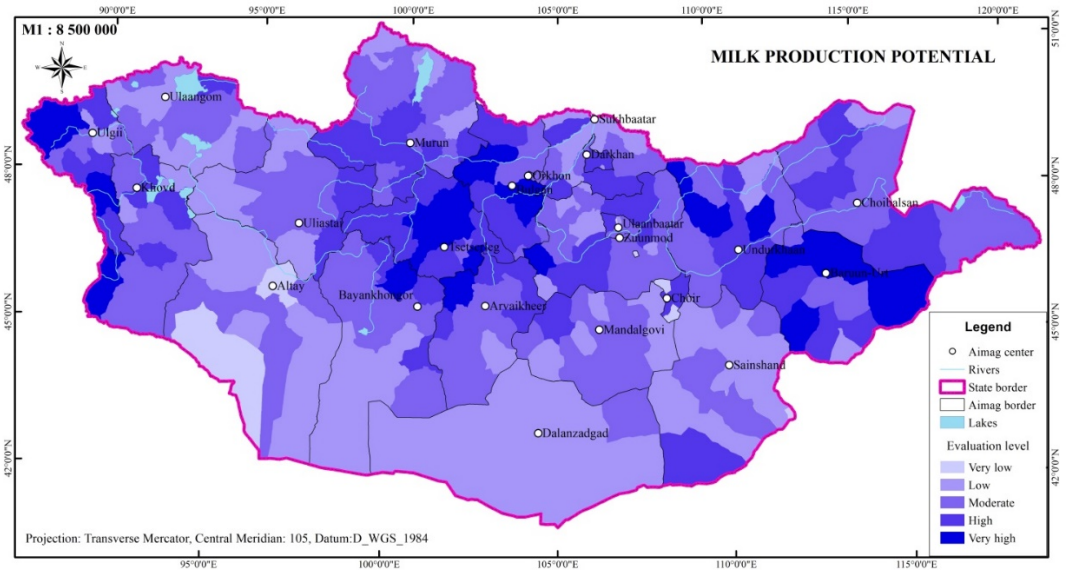

Figure 2. Milk production potential

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Assessment of wool and cashmere production potential

According to the research results, an average of 38432.27 tonnes of wool and cashmere is produced annually from agriculture, of which 26671 tonnes or 69 per cent are sheep wool, 8108.2 tonnes or 21 per cent are goat cashmere and 1209.6 tons or 3 per cent are camel wool. Aimags in the Khangai region accounts for 32-37 per cent of the total output of sheep wool and goat cashmere. In terms of camel wool production, the Central region, especially Umnugovi Aimag, accounts for the majority of total production.

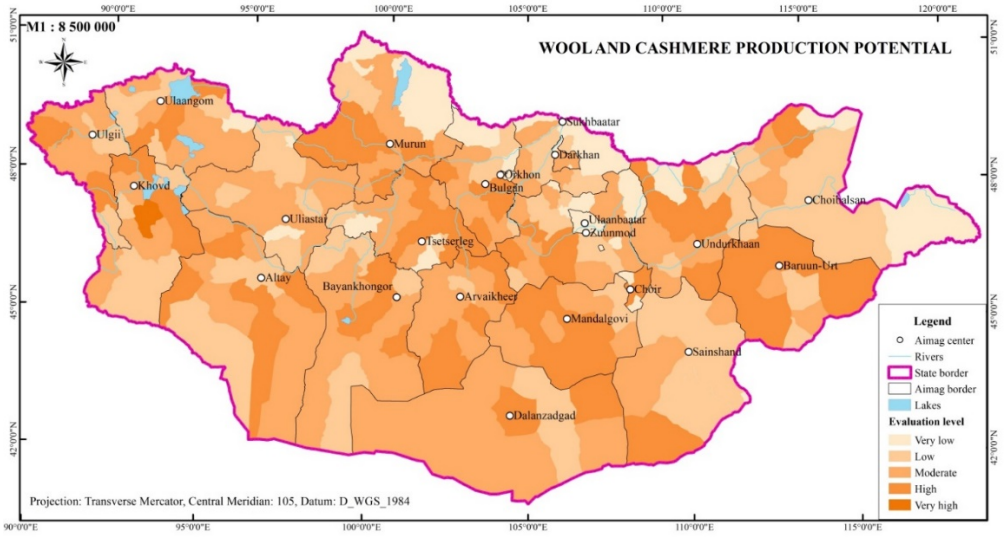

Figure 3. Potential of wool and cashmere production

Assessment of meat (by slaughter weight) and skin (hides) production

According to the research results, on average of 13512.73 thousand hides and skins can be produced form livestock, of which 7 per cent are cowhides, 49 per cent are sheepskins and 42 per cent are goat skins. In terms of meat production, 288.3 thousand tonnes of meat was prepared,,of which 35.6 per cent was mutton and 22-28.4 per cent was beef and goat meat. The aimags of the Khangai region produce 103.2 thousand tonnes of meat per year, which alone accounts for 36 per cent of the total meat production. In the western and central regions, 63-72 thousand tonnes of meat is produced annually, which is 21-25 per cent of the total meat production.

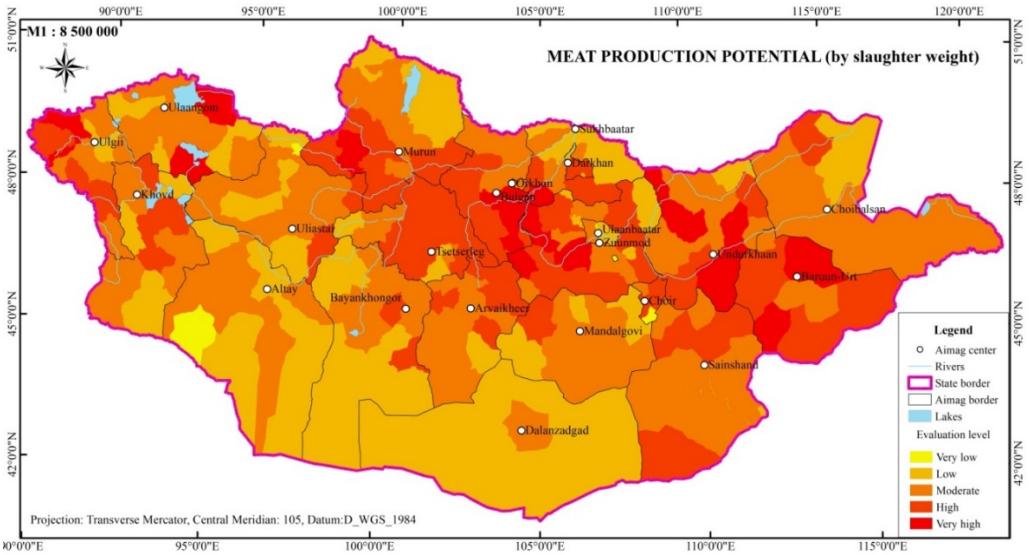

Figure 4. Potential of meat production (by slaughter weight)

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Tuv, Bulgan, Arkhangai, and Khuvsgul aimags are leading in horse and cattle hides and sheepskins, Umnugovi, Dornogovi, and Bayankhongor aimags are leading in camel hides, and Bayankhongor, Tuv and Uvurkhangai aimags are leading in goat skins. 35.9 per cent of the total hides and skins produced in the country come from the Khangai region aimags (4857.23 thousand skins), 23-25 per cent from central (3220.18 thousand skins) and western region aimags (3326.15 thousand skins). The Central region is the main producer of camel hides and the Khangai region is the main producer of other hides and skins.

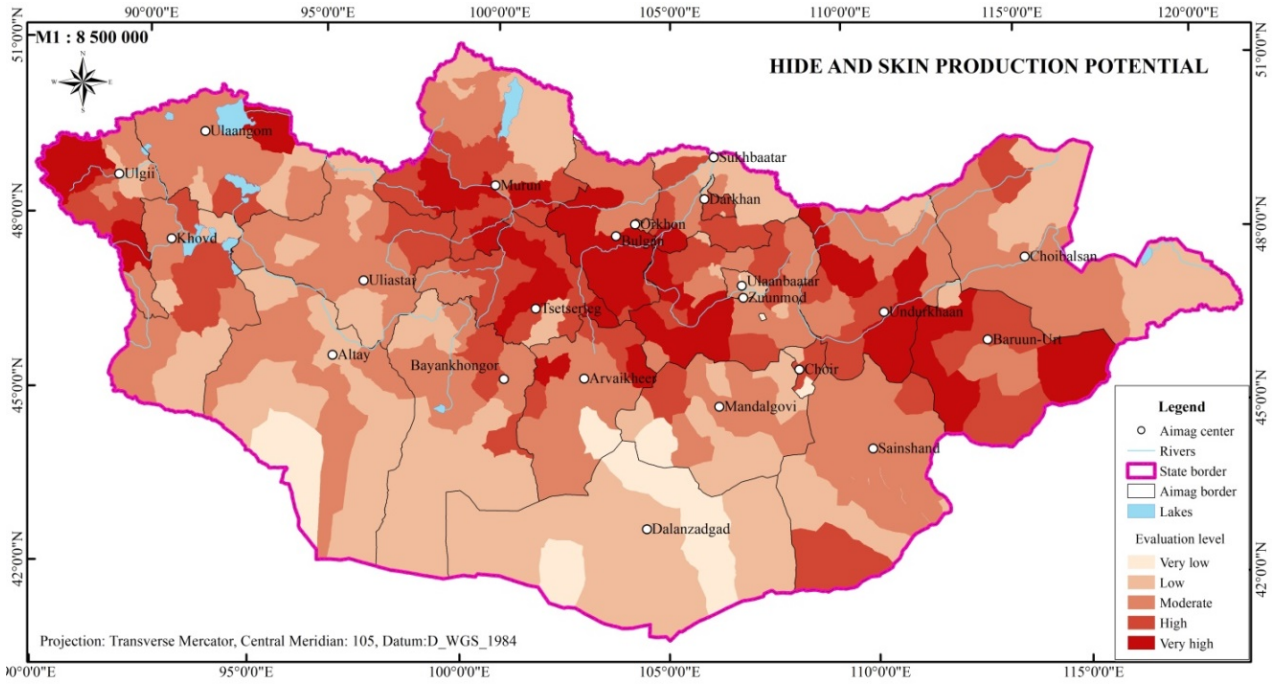

Figure 5. Potential of hides and skins production

Crop production

An average of 364.2 thousand tonnes of grain, 152.8 thousand tonnes of potatoes, 48.5 thousand tonnes of fodder plants, 88.3 thousand tonnes of vegetables, and 1080.5 thousand tonnes of hay are harvested annually in Mongolia. 70 per cent of the total harvested grain, 58-68 per cent of potatoes and vegetables, and 50.6 per cent of fodder plants come from Tuv, Selenge and Darkhan aimags of the Central region.

34.4 per cent of all hay is collected from Khuvsgul and Bulgan aimags of the Khangai region. In terms of harvested grain, Tsagaannuur (36552.4 tonnes), Khushaat (18186.3 tonnes), Saikhan (17685.3 tonnes), Yeruu (17630.0 tonnes), Tushig (13698.0 tons) soums of Selenge aimag and Tarialan soum of Khuvsgul aimag, Orkhontuul soum of Selenge aimag, Khongor soum of Darkhan aimag and Jargalant soum of Tuv aimag each harvest more than 12 thousand tonnes of grain on an average annually. In terms of harvested potatoes, Jargalant soum of Tuv aimag harvests an average of 38,734 tonnes of potatoes per year, which alone accounts for ¼ of the total potato harvest in the country. In addition, Bornuur soum produces about 8360 tonnes per year, Mandal (6594.2 tonnes), Tsagaannuur (6054.3 tonnes), Saikhan (5263.3 tonnes), Orkhon (4575.1 tonnes) soums of Selenge aimag, Khovd city of Khovd aimag and Khongor soums of Darkhan aimag harvest about 3000-3500 tonnes of potatoes on an average.

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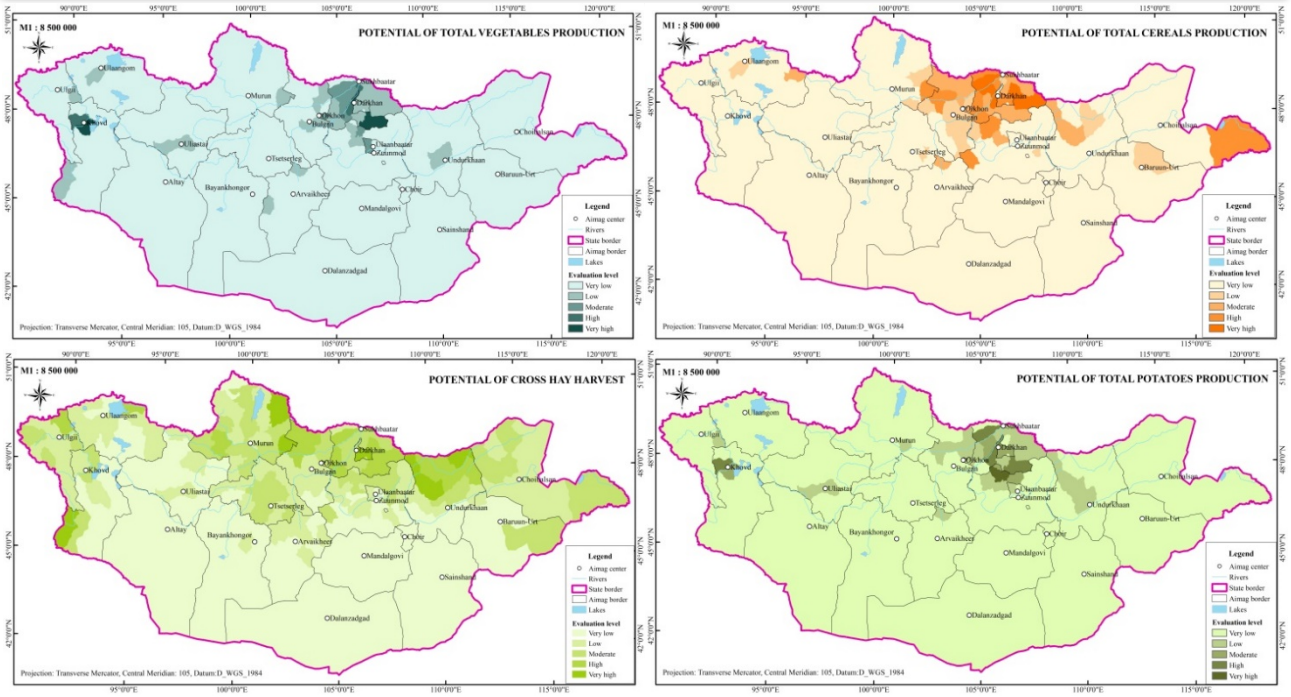

Figure 6. Potential of total crop output

Assessment of natural resource potential (based on agricultural production resource)

The assessment of natural resource potential (based on agricultural production resource) showed that 41.0 per cent (641287.6 km^2) of the area studied had average potential, 34.8 per cent (544312.4 km^2) had very low potential, and 19.4 per cent (303438.5 km^2) had high potential. However, only 2.3 per cent (35974.7 km^2) of the area had very high potential, while the same amount of area (2.5 per cent of the total area covering 35974.7 km^2) had very low potential.

Table 6. The result of natural resource potential evaluation

Evaluation level	**Area**	
	km^2	**%**
Very low	35974.7	2.3
Low	544312.4	34.8
Moderate	641287.6	41.0
High	303438.5	19.4
Very high	39102.9	2.5

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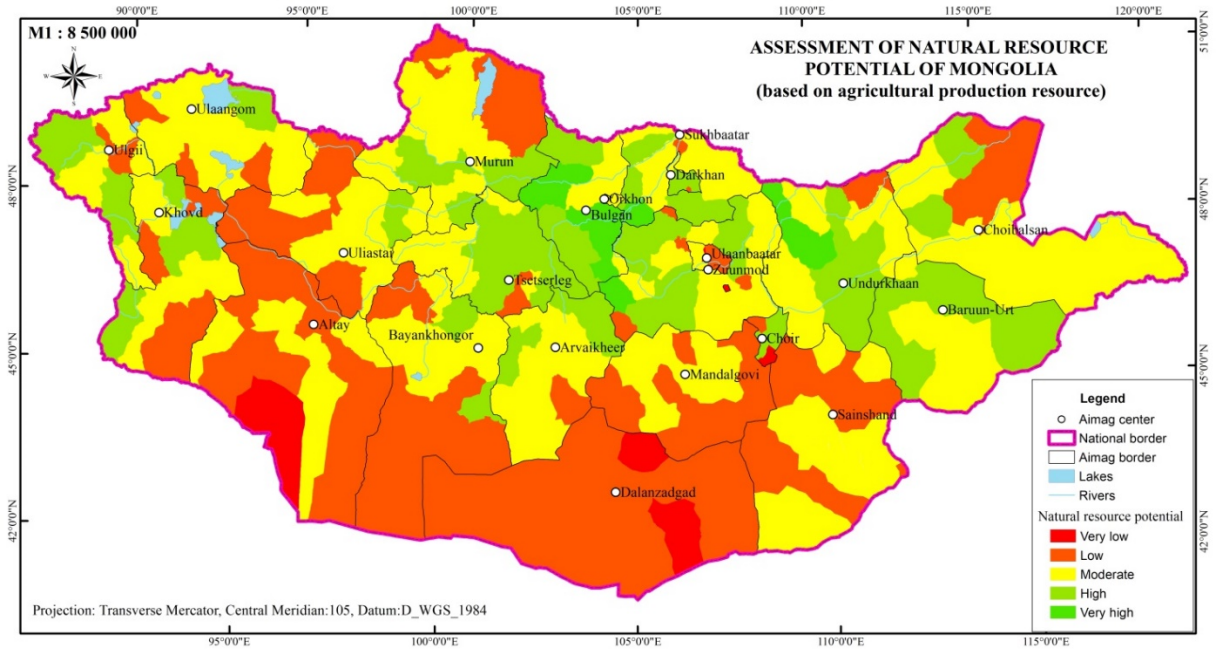

Figure 7. Assessment of natural resource potential (based on agricultural production resource)

Table 7. Assessment of natural resource potential of landscape (by natural zones and belts)

Natural belts and zones	Area of natural zones, km^2	Of which: Area for each evaluation level, in %					Total percentage of high and very high evaluation levels	Level of potential
		Very low	Low	Moderate	High	Very high		
Alpine	55351.5	-	34.5	40.5	19.8	5.2	25	IV
High mountain	70894.3	0.5	17.3	56.5	25.7	-	25.7	III
Forest steppe zone	236013.0	-	8.2	50.8	33.0	8.0	41.0	I
Steppe zone	540835.6	0.2	17.0	49.4	30.9	2.5	33.4	II
Gobi zone	358568.5	1.5	50.3	41.3	6.9	-	6.9	V
Desert zone	302453.2	10.5	72.1	15.4	2.0	-	2.0	VI

In terms of natural belts and zones, 52.7 per cent (18958.3 km^2) of the 35974.7 km^2 of the "very high" potential is in the forest-steppe zone, 37.1 percent (13346.4 km^2) is in the steppe zone, especially in the meadow steppe and steppe sub-zones, and 10.2 percent (3669.3 km^2) belongs to the alpine belts. It is worth mentioning that in the alpine belt, the area with "very high" natural resource potential of the landscape is only in Umnudelger soum of Khentii aimag. In other words, the result of the research suggests that the forest-steppe zone has higher natural resource potential than other natural belts and zones. And the steppe zone is ranked after the forest-steppe zone in terms of natural resource potential since 54.7 percent (165980.9 km^2) of the area rated as "high potential" was in the steppe zone, whereas 25.7 percent (77983.7 km^2) was in the forest-steppe zone. 81.7 percent (31947.07 km^2) of the total area, which is assessed as "very low" in terms of natural resource potential of the landscape, is located in the desert zone, especially in the arid sub-zone, and 14.3 percent (5591.7 km^2) in the Gobi zone.

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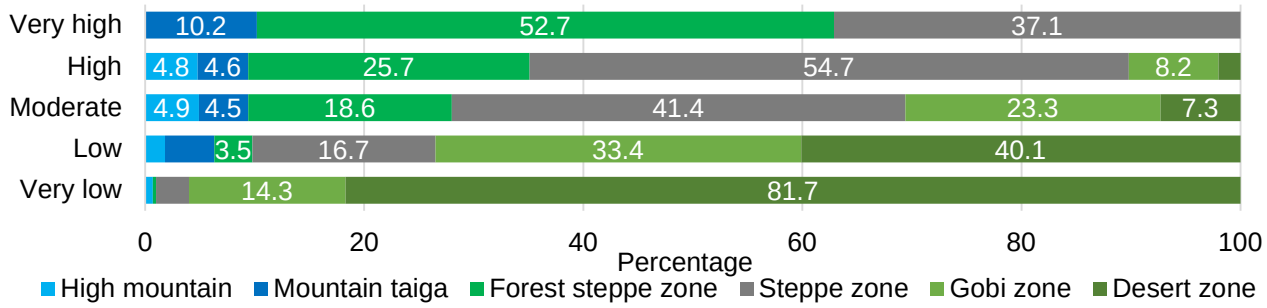

Figure 8. The result of natural resource potential, by natural zones and belts

There is no experience in Mongolia in determining the potential of natural resources in a landscape, solely based on agricultural production, according to the valuation methodology combined with the market price method and multi-criteria decision-making method. However, projects and research works are ongoing to determine which areas are most suitable for industrial development and some research is being conducted in this area that can be put into practice at the level of the country's policy and planning. For instance, Battogtokh, D and other researchers of the Institute of Geography and Geoecology, MAS [26] have published an article entitled "State industrial policy of Mongolia: Special industry mapping in the eastern region of Mongolia". The researchers have developed a scientific methodology for the development of a unified industrial mapping and propose to use this methodology to develop a mapping and planning of Mongolia's industries/industry development across the country's 5 regions (western, eastern, central, northern, and southern regions). Furthermore, this study was conducted to determine which areas are most suitable for industry development and the type of industry development that is relevant. The method also utilizes the Spatial Multi-Criteria Decision Analysis (MCDA) method of selecting 12-15 factors for each sector, depending on industrial peculiarities and based on information from the eastern region (referencing 29 data sets on the environment, ecology, socio-economic and population) [26].

According to the articles and research cited in our article, the market pricing was the main and most widely used method of assessing the natural resource potential of the landscape. Therefore, milk, wool, meat, leather and some agricultural products were selected in the sense that they can be valued and sold in the market. However, in order to use the market price method, it is necessary to determine the volume of production, so we used the "Methodology for calculating GDP", approved in Mongolia. Even though the evaluation methodology used in our study has not been used much before, but it is considered acceptable, because it is based on methods that are somewhat accepted in Mongolia and internationally.

In order to more accurately determine the order of importance of each livestock produce, the analytical hierarchical process was performed to differentiate the types of livestock species. According to the results, most influential indicators were following: cow's milk for milk production potential, sheep wool for the potential of wool and cashmere production; mutton for meat production potential, goatskin for the potential of hides and skins production. Later, in the development of the integrated potential assessment, the indicators that had the greatest impact on agricultural production potential were wool, cashmere and milk production.

Even though the purpose of this study was to assess the overall state of the natural resource potential of the landscape. based solely on the amount of agricultural production, natural and other social factors, such as the frequency of droughts and dzud (severe winter with heavy snowfall), pasture degradation, and social activities to improve livestock productivity, which can significantly affect livestock husbandry, should be considered. For this reason, we recommend that climate, environmental and social indicators should be added to further refine the study as an evaluation criterion.

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CONCLUSIONS

In terms of the natural resource potential of the landscape (based on agricultural production resource), only 2.3 per cent of the total area had "very high" potential. These areas include Bulgan, Bayan-Agt, Buregkhangai, Dashinchilen, Orkhon, and Khutag-Undur soums of Bulgan aimag, Orkhontuul soum of Selenge aimag, Erdenesant soum of Tuv aimag and Umnudelger soum of Khentii aimag. The territory of Erdenesant soum of Tuv aimag, Buregkhangai soum of Bulgan aimag, Orkhontuul soum of Selenge aimag are located in the steppe sub-zone, Umnudelger soum of Khentii aimag and Dashinchilen soum of Bulgan aimag are located in the meadow steppe sub-zone. Of these, the soums of Bulgan aimag belong to the Tuul sub-province of the steppe zone and the northeastern sub-province of the Khangai mountain range and are located in the small mountain-steppe zone along the Orkhon-Tuul river basin. The territory of the soums is a combination of steppes with mountains and hills, so it is very suitable for livestock breeding, agriculture, and tourism.

Erdenesant soum of Tuv aimag, which is also rated "very high" in terms of potential, is located in the southern part of the Khangai Mountain forest-steppe zone, adjacent to some Gobi desert regions, and leads the aimag in total number of cattle, horses and sheep. And Orkhontuul soum of Selenge aimag is a soum with unique ecological harmony, which is a combination of grass steppe and forest-steppe zone in the northern part of the steppe zone of the country. Umnudelger soum of Khentii aimag is located in the forest-steppe, mountain taiga belt, and meadow sub-zone, and the northern part of the territory is located in the Khentii mountain range, so this area is the densest wetland in the river network of the country. The soum provides about 50-60 per cent of the Khentii aimag's grain harvest and half of the forage crop.

In terms of natural resource potential of landscape, the "very low" category includes Bayan-Ovoo, Tsogt-Ovoo, and Altai soums of Umnugovi aimag, Shiveegovi soum of Govisumber aimag and the capital city. Altai soum of Govi-Altai aimag, which is included in this category, is located at an altitude of 1100-3802 meters above sea level and it has a lot of heat resources but has a lack of moisture, since it location is a continuation of the Altai mountain range in the desert region of Aj Bogd. The soum has Gobi steppe with mountains and hills, so it is possible to develop camel and goat breeding. In terms of crop production, the soum is not engaged in grain and fodder crop production, and according to the end-of-year livestock census, goats make up about 75 per cent of the total herd.

In summary, leading soums in terms of livestock numbers at the national and aimag levels, especially the soums with the highest number of cattle can be evaluated as "very high" or "high" in terms of potential assessment according to the hierarchy of criteria used in the hierarchical analysis. On the other hand, the soum leads the aimag in the number of livestock but in terms of herd composition, the predominance of horses and camels may contribute to the soum being assessed as "moderate" and "low" in the assessment of natural resource potential.

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