DETERMINATION OF POTENTIAL WATER POND LOCATION USING ARCHYDRO MODEL AND SUITABILITY ASSESSMENT

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Abstract: This research work was carried out in order to test the methodology of determining the suitable place for the construction of ponds locations. We applied based on multi-criteria analysis method and Arc hydro modeling of geographic information system (GIS). The study area of this research is in Khaliun soum of Gobi-Altai aimag. The objectives of this study was to determine potential water pond location based on GIS analysis and to evaluate suitability assessment. To do that the evaluating the suitable place for the construction of a new floating pond by the method of basic conditions (constraint map) and multiple criteria (factors map) and calculating the integrated assessment of suitability have been put forward and completed. According to the results of the integrated assessment of the construction of ponds land, if the basic conditions of the currently used land are excluded, 7.09 percent or 2952.19 hectares of the total territory of Khaliun soum of Gobi-Altai Province are basic conditions, 2.26 percent or 940.27 hectares are extremely unsuitable, and 68.9 percent or 28692.13 ha are unsuitable, 21.7 percent or 9058.43 ha are limited suitable, and 0.03 percent or 11.48 ha are suitable. This research will be useful for the agricultural management especially for the against dryness.

Keyword: surface water, runoff modelling, suitability

INTRODUCTION

One of the most widely used Geographic Information System (GIS) methods in land planning and land management is land use suitability mapping and analysis. Generally, land use suitability assessment is the activity of defining the appropriate purpose by comparing the most favourable spatial conditions of future land use with certain criteria [1]. In recent years, land use suitability analysis based on GIS has been widely used around the world. But for our country, land use suitability assessment is in the beginning stage. Reduction of surface and groundwater resources due to global climate change and improper land use has a significant negative impact on land use [2]. For this reason, it is very important to identify and map suitable places to collect snow and rainwater and build ponds and ponds in agricultural water management. Correspondingly, it is not necessary to make the possible location of water ponds only based on possibility assessment, and it is important to estimate the pattern of surface water flow of the basin and to produce results in combination with suitability assessment.

OBJECTIVES

Surface water flow modelling and assessment of suitability is to determine the suitable location for the construction of ponds in Khaliun soum of Gobi-Altai province. The following objectives are proposed:

- Determining the basin's surface water flow, drainage, and catchment area using the ArcHydro Model
- To assess suitability for some environmental and land use factors
- To define the location of the potential land for pond construction

STUDY AREA

The center of Khaliun soum of Gobi-Altai Province is located at the foothills of Khar Azarga mountains, which is a continuation of Shargyn Gobi. It is situated 1026 km away from Ulaanbaatar, 112 km from Altai City. Khaliun soum is administratively divided into 4 bags: Olonbulag, Suuj, Guu bariach and Chatsran. The soum territory is 5214 km². The soum center is 1460 meter above the sea level, the highest point is mountain Burkhan Buudai 3765 meters, the lowest point is the Bor Point Canal 1010 meters. 2/3 of soum's territory is Gobi covered with valleys, plains and steppes, 0.5% or 24.5 km² of land is covered with forests, and 0.3% is mountainous with rocks.

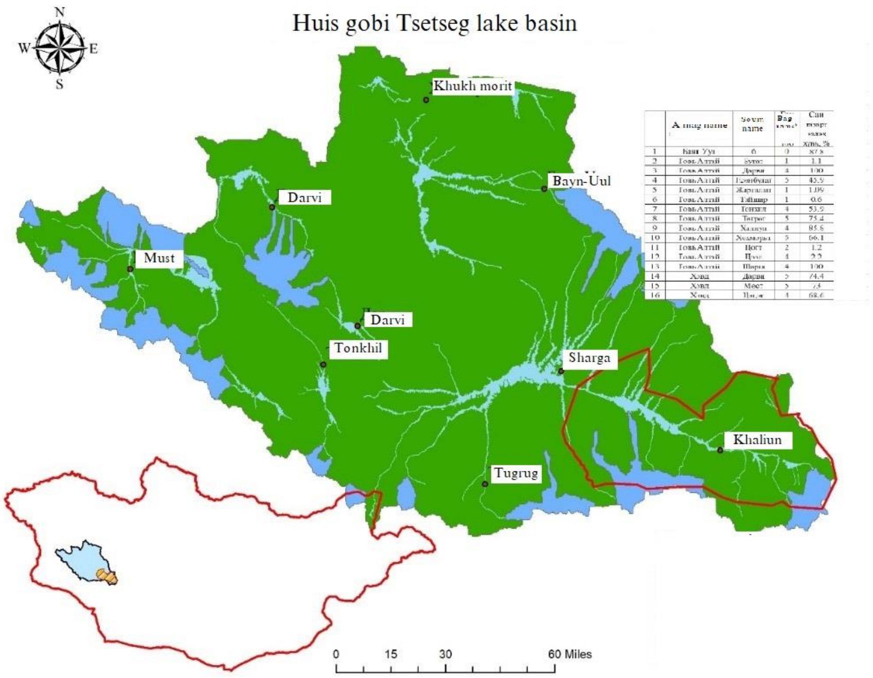


Figure 1. Study area

METHODOLOGY

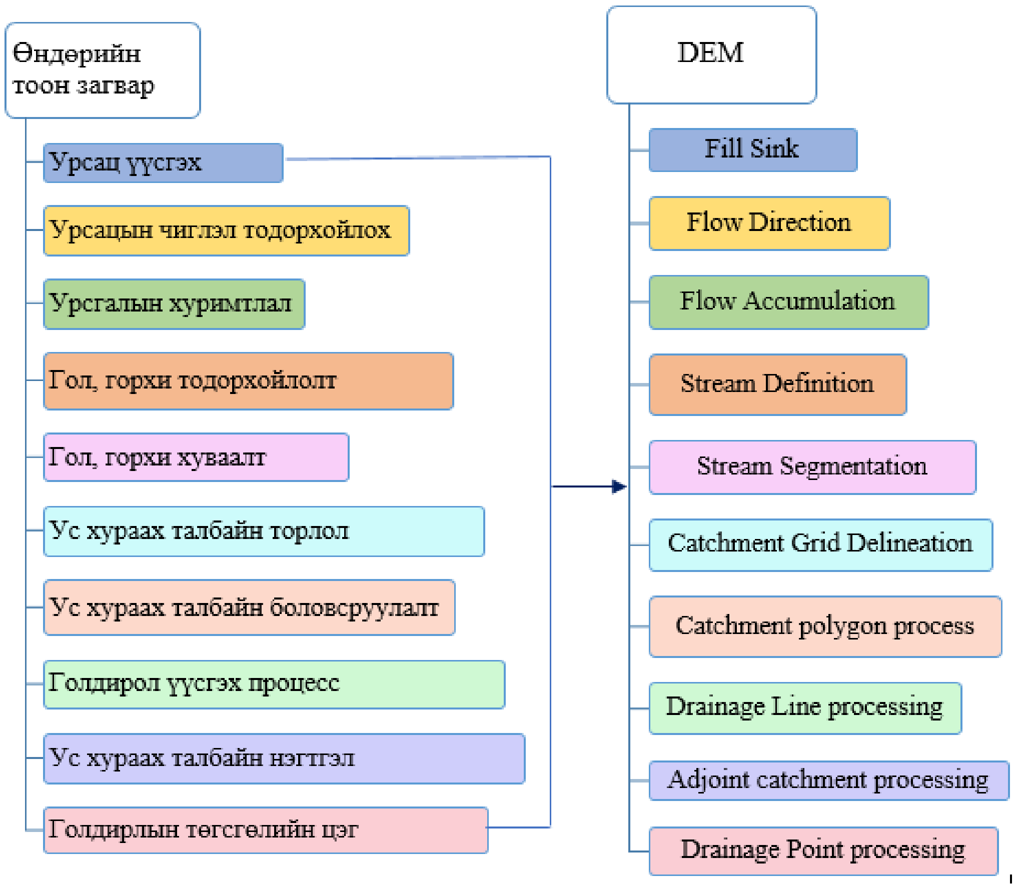
The methodology of multifactorial analysis is based on the technology of GIS [2]. The study consists of three phases: baseline assessment, surface water flow modelling using the ArcHydro model, and multi-factor analysis to determine a suitable area. At the first step, the basic conditions for meeting the most basic planning requirements are established. In other words, the areas that can be used for ponds and ponds that are currently being used for specific purposes (towns, roads, forests, agricultural fields, etc.) will be determined. In the second step, the water flow line and catchment area model will be determined as a result of the 9-level map processing, which is carried out according to the priority order by the ArcHydro model. In the third step, multivariate analysis is performed using AHP (Analytic Hierarchy Process) software using weighted averages. Baseline and factor studies were established using the Alos-Palsar satellite digital elevation model (DEM) with a resolution of 12.5 meters and quantitative maps of factor evaluation criteria [4,5].

To find the weighted values, the method of paired comparison was applied [6]. All types of influences and factors are weighed and overlapped, and the most correct and realistic relationship between them is determined [7,8].

$$S=\sum w_i x_i \qquad \text{(I)}$$

S = Suitability of the object; w_i = Weighted average of factors [Sum of weighted average of all factors equals 1 or 100%]; x_i= Criterion factor score

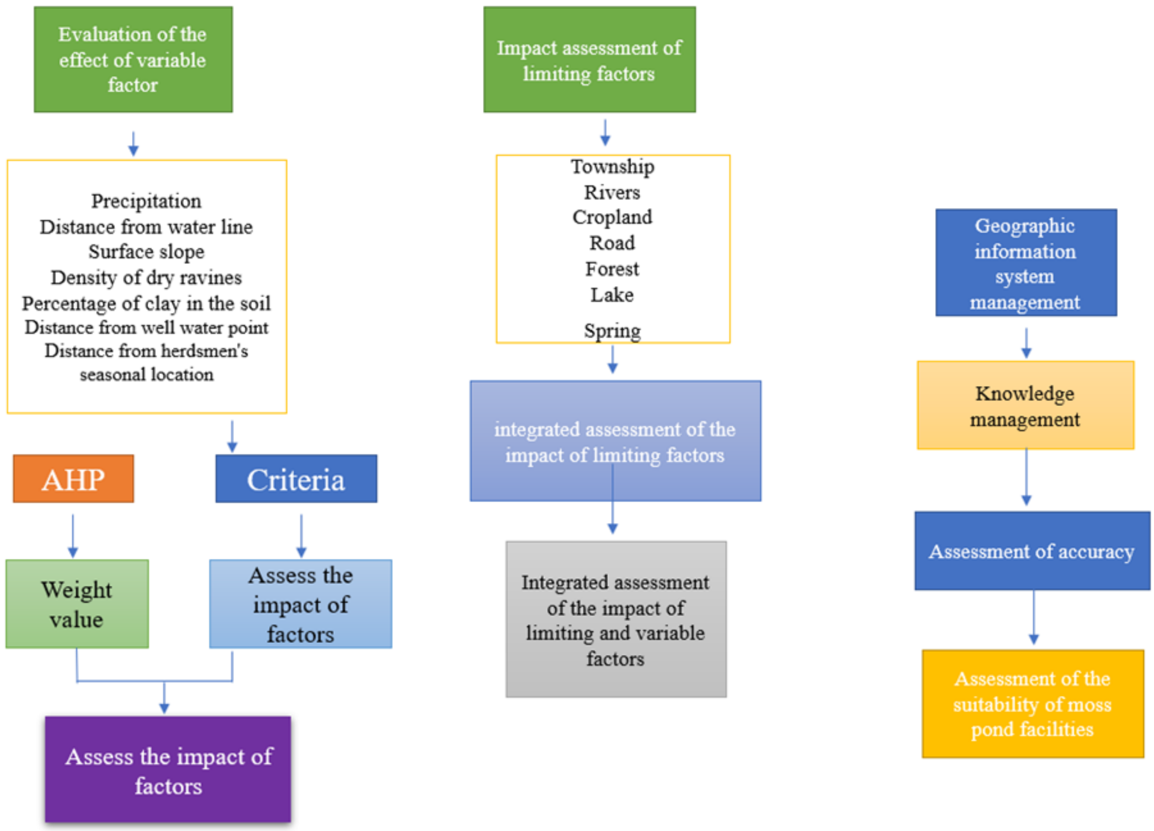
We used the Analytical Hierarchy (AHP) method to derive the impact and factor evaluations [6]. It is necessary to carefully check the correctness of the assessment of effects and factors, which was determined by the method of Saatii (2006) [7,9]. Impact and factor ratings were determined as weighted values using the online AHP priority calculator [7]. Factors were ranked and relative weights were determined by establishing pairwise correlations.



Schema 1. Flow modeling determination by Archydro model

Flow modeling determination methodology

Using the ArcHydro add-on for ArcGIS, the schema for determining flow modeling was developed based on the book "Geographical Information System of Water Resources" published by the US company ESRI (ESRI 2002). This ArcHydro add-on model uses the Alos Palsar 12.5 meters DEM to determine flow direction, flow storage, potential channels, river gradients, catchment areas, channel terminations and junctions according to schema 1.



Schema 2. Methodology for suitability assessment using multivariate analysis

Methodology for Suitability Assessment: According to schema 2, suitability assessment was carried out for natural factors such as rainfall, water flow, water catchment area, surface slope, soil clay content, gully density, while for land use, distance from agricultural fields, distance from herdsmen's location, the distance from the well water point and the distance from the well water point were selected and multi-factorial analysis method was combined with the Analytical Hierarchy Process (AHP) method to evaluate suitability.

Table 1. Spatial criteria for multivariate analysis

Rank	Criterion	Evaluation	Normalized value	Rank	Criterion	Evaluation	Normalized value
I	Precipitation (mm)	>300	4	V	Percentage of clay in the soil (%)	>1	4
		200-300	3			0.75-1.0	3

		100-200	2			0.5-0.75	2
		<100	1			<0.5	1
II	Distance from water line (m)	<500	4	VI	Distance from Farmland (km)	<3	4
		500-1000	3			2-3	3
		1000-2000	2			1-2	2
		>2000	1			>1	1
III	Surface slope (degrees)	<3.0	4	VII	Distance from well water point (km)	>5	4
		3-5	3			4-5	3
		5-10	2			3-4	2
		>10	1			<3	1
IV	Density of dry ravines (km2/km)	>1	4	VIII	Distance from herdsmen's seasonal location (km)	<2	4
		0.75-1.0	3			2-3	3
		0.5-0.75	2			3-4	2
		<0.5	1			>4	1
		0.75-1.0	3			2-3	3
		0.5-0.75	2			3-4	2
		<0.5	1			>4	1

RESULTS

Global climate change is taking place strongly in Mongolia, the balance of nature and ecology is being lost, desertification is increasing, water resources are becoming scarce, the vegetation and soil structure of each area are changing, the force of the wind is increasing, droughts are continuing to occur, and catastrophic phenomena are increasing. has a significant negative impact on land degradation and land use. For this reason, it is necessary to accumulate snow and rainwater in areas without surface water sources to improve livestock and population water supply, and use it for purposes such as agriculture, natural restoration, tourism, etc. [1]. In order to improve water supply by collecting snow and rainwater for pastures and crops, we assessed the suitability of ponds by using the methodology approved by Annex 9 of the order of the head of the Regional Development Authority No. A/205 of 2015 and using the Archydro model to determine surface water flow.

1. Baseline assessment

Constraint maps were created taking into account existing urban areas, agricultural fields, highways, mining areas, lakes, springs, wells, water points, etc. In doing so, a thematic image was created for each of the selected indicators, and the analysis of choosing a suitable place for a float and pond was performed by overlaying the images on the ArcGIS program [10].

Table 2. Criteria for the location of ponds and ponds

Type of use	Ball	Action to be taken
Farmland	0	Can't be on existing farmland

Existing urban areas	0	Do not be in an existing residential area
Highway	0	Do not overlap with the highway
Mining area	0	Do not be in licensed mining areas
Lake	0	No need for regular water
Forest	0	Due to its high water absorption capacity, surface runoff does not occur
Springs, wells, water points	0	It is not necessary to be near springs, wells or water points

Source: Pond Suitability Assessment, GGCC. 2015.

The base condition map is made by Boolean map method taking into account the above factors. In a Boolean map, a data value has two value conditions: 0 and 1. A conditional value of 0 represents an impossible or disallowed condition, and a conditional value of 1 represents an allowable or possible value (Figure 1).

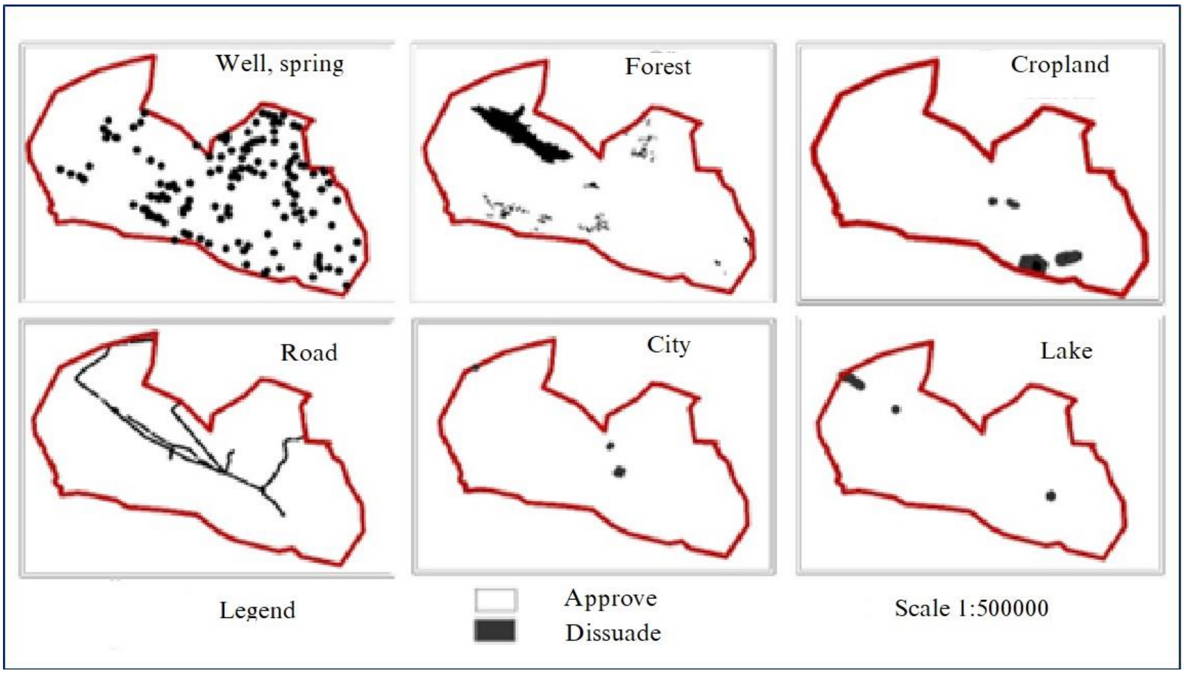


Figure 2. Map of criteria and factors for the basic conditions for the suitability of the land for the construction of ponds

The image above is mapped using the conditional value method of Boolean maps, and areas showing a value of 0 are considered inappropriate. In the figure, inappropriate or 0 values are shown in black and suitable or 1 values are shown in white. The images of the above baseline conditions were combined to produce a composite assessment image (Figure 3).

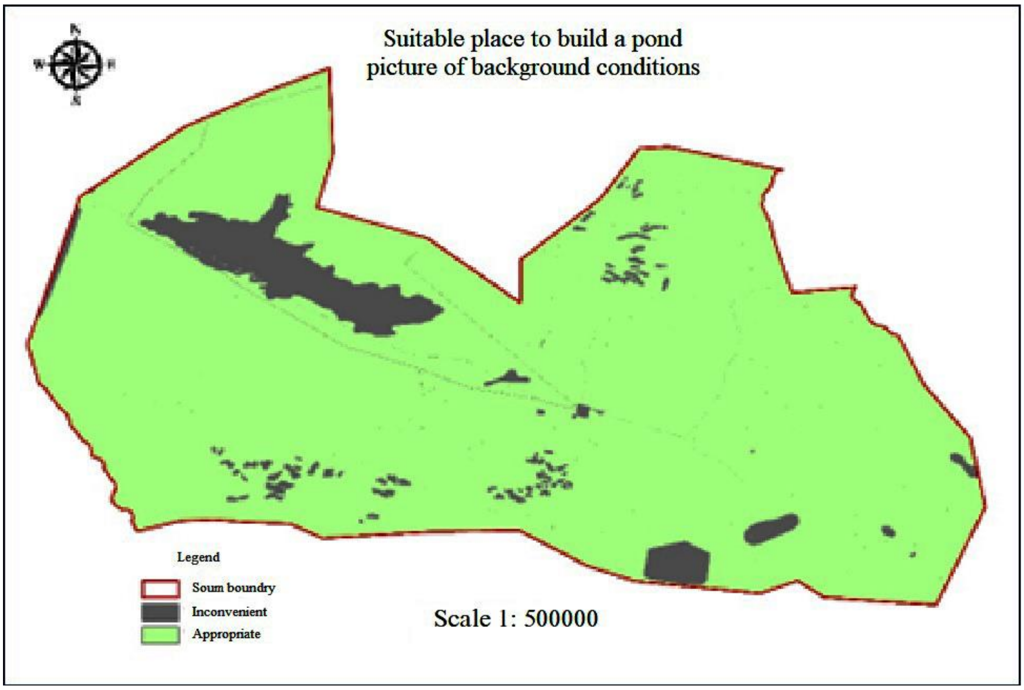


Figure 3. Suitability of the site for the construction of a pond picture of background conditions

In the figure above, the value of 0 is shown in black, and the value of 1 is shown in green. According to the evaluation of the basic conditions, 92.9 percent or 38,823.9 hectares of the total area of Sumy are permitted, and 7.0 percent or 2,960.1 hectares are prohibited.

2. Evaluation of factors

This method is used when many factors are used in the suitability assessment. When comparing multiple factors, one is more important than the other and will have a higher weight in terms of weight. AHP (analytical hierarchy process) was used to rank the criteria (Saaty 1977) [11]. This method determines the weight value by the criteria ranking matrix. The selected factors were ranked by their importance to determine the weight values of the criteria using a ranking matrix, and the factors used in the study were ranked by their importance in influencing the suitability of ponds and ponds (Figure 4).

Cat		Priority	Rank	(+)	(-)
1	Precipitation (mm)	33.0%	1	19.0%	19.0%
2	Distance from water line (m)	19.5%	2	5.4%	5.4%
3	Surface slope (degrees)	14.4%	3	6.0%	6.0%
4	Watershed	13.1%	4	6.0%	6.0%
5	Density of dry ravines (km2/km)	9.2%	5	4.0%	4.0%
6	Percentage of clay in the soil (%)	4.5%	6	2.8%	2.8%
7	Distance from Farmland	3.0%	7	1.6%	1.6%
8	Distance from well water point (km)	1.8%	8	0.8%	0.8%
9	Distance from herdsmen's seasonal location (km)	1.5%	9	0.8%	0.8%

Number of comparisons = 36
Consistency Ratio CR = 8.5%

Figure 4. Site factors for the construction of a cotton pond ranked and weighted

From the ranking above, the most important factors are the surface slope and soil stability, and the least important is the groundwater level. The consistency ratio of the weight value calculated by the ranking matrix is 8.5% or 0.085.

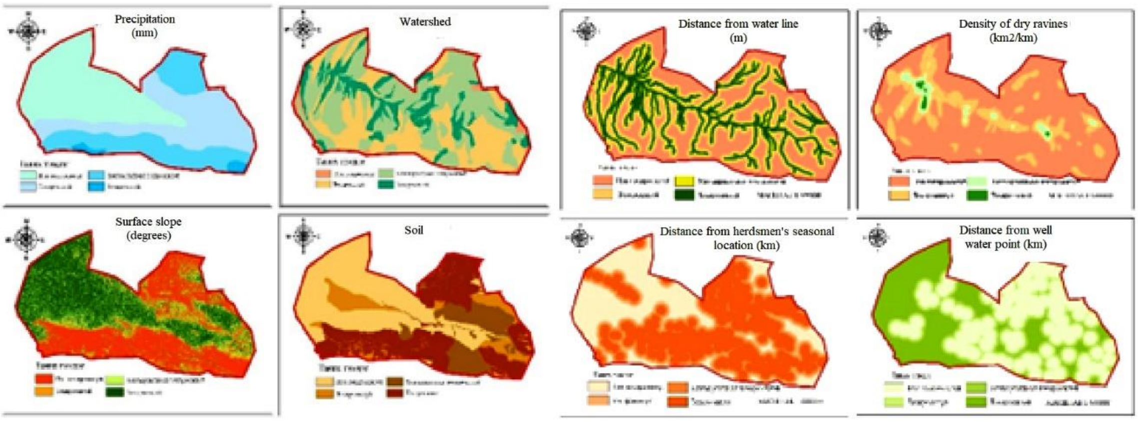


Figure 5. Suitability of the site for the construction of a cotton pond factor rating diagram

The evaluation map of the above factors was developed using the neighborhood function, spatial zoning, and digital surface model in ArcGIS software, and it was evaluated on a scale of 1-4 points: extremely unsuitable, unsuitable, limited suitable, and suitable.

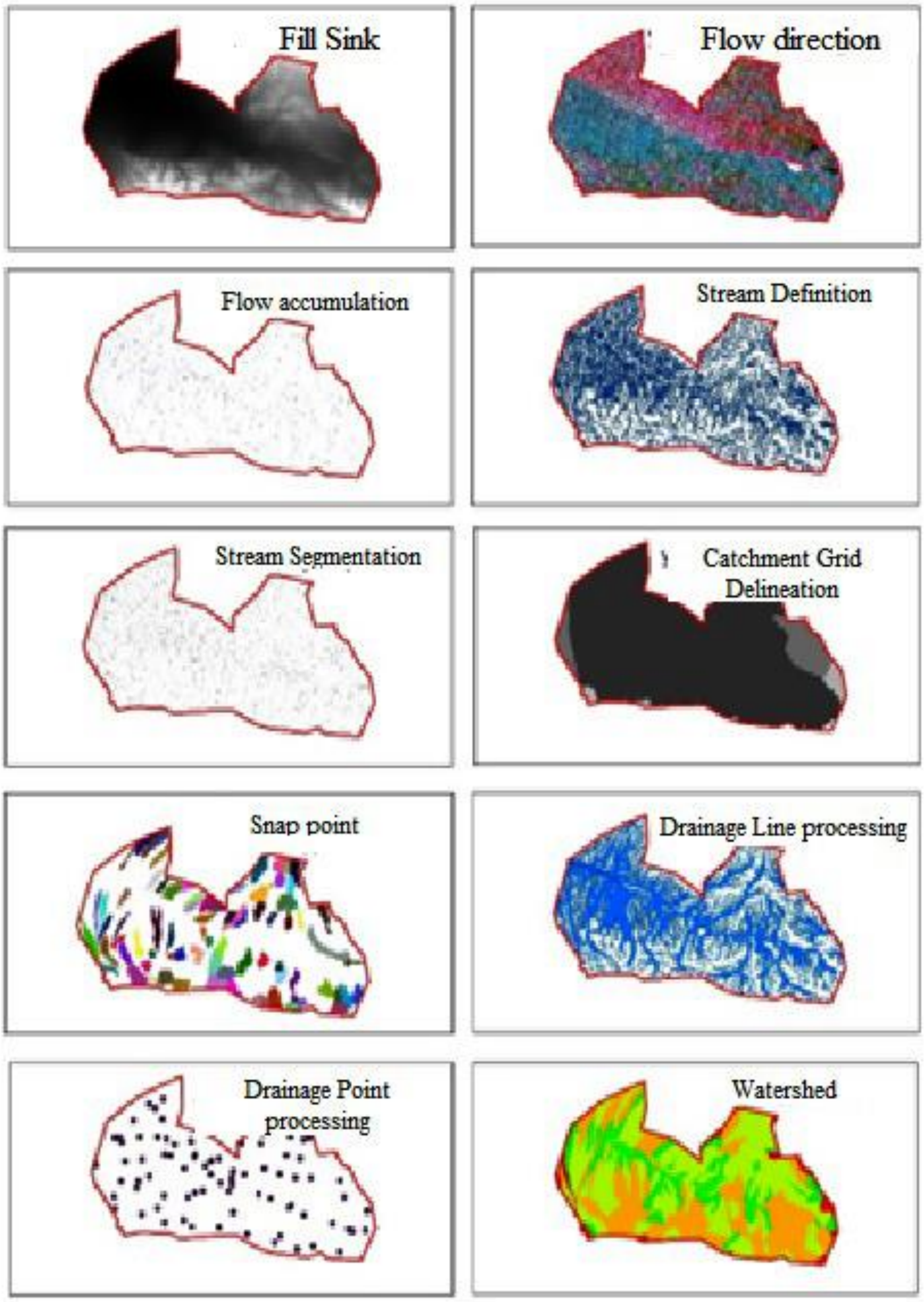


Figure 6. Surface water flow factors as determined by the Archydro model

3. Integrated suitability assessment

An integrated picture of the basic conditions and factors for the suitability of the land for the construction of a pond was made (Figure 7).

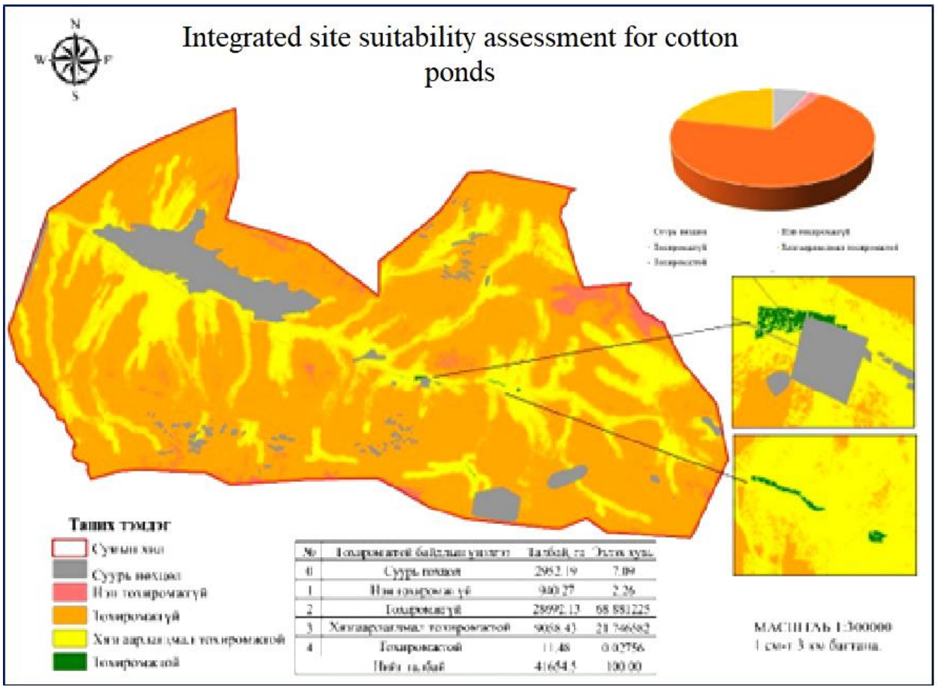


Figure 7. Integrated assessment of the suitability of the site for the construction of a sponge pond

The picture of the integrated assessment of the suitability of the site for the construction of ponds and ponds was classified as suitable, limited suitable, unsuitable and very unsuitable.

Table 3. Suitability of land for pond construction integrated assessment of the situation

№	Suitability assessment	Area, ha	Occupancy rate
1	Basic condition	2952.19	7.09
2	Very inappropriate	940.27	2.26
3	Inconvenient	28692.13	68.88
4	Limited suitability	9058.43	21.75
5	Appropriate	11.48	0.03
Total area		**41654.50**	**100.00**

Based on the results of the integrated assessment of the suitability of the land for the construction of ponds and ponds, 0.03 percent or 11.48 hectares of the total area of Khaliun soum of Gobi-Altai Province is suitable, 21.75 percent or 9058.43 ha are limited suitable, 68.88 percent or 28692.13 ha are unsuitable, 2.26 percent or 940.27 ha are extremely unsuitable, and 7.09 percent or 2952.19 ha are considered basic conditions.

DISCUSSION

In Mongolia, the traditional folk method of building ponds and ponds has been handed down since ancient times, but the work of establishing them using scientific methods covering a large area has been neglected until now. We conducted this research to increase water supply by accumulating snow and rainwater for agricultural production, mainly for agriculture and agriculture. Ing geotekh LLC, commissioned by the Ministry of Agriculture and Forestry, for the first time developed a map of suitability for the construction of floating ponds on a geographic information system [10] and approved the methodology in Annex 9 of Order No. A/205 of 2015. This methodology is vague, and the hierarchy and methodology of how to calculate influencing factors are unclear, so we propose our own methodology, believing that there is a legitimate need to improve it. Altansukh et al. (2017), who developed the work mentioned above, also published an article on this topic [13]. Also, P. Myagmarceren and I. Myagmarjav published articles on this topic in 2017 and 2019 [1,14]. In our study, we tried to improve the ideas proposed by these scientists with more criteria. In the future, in the modelling of the site for the construction of floating ponds, geological-geomorphological parameters (sediment type, bedrock properties, etc.) and climatic factors (precipitation, sediment intensity, evaporation, etc.) should be calculated [12], and detailed for Khaliun soum as there is no information, it could not be included in the methodology.

CONSLUSSION

When carrying out the assessment of the suitability of the site for the construction of the cotton pond, the assessment of the basic conditions and factors was carried out. Thematic layer or weight value of each factor is calculated by AHP or ranking matrix method for each factor image, and the weight value of each thematic layer is multiplied and added to the assessment of suitability for building a new floating pond. The following results are obtained.

- In the assessment of the basic conditions for the suitability of the construction of a cotton pond, 92.91 percent or 38823.95 hectares of the total area of Sumy are permitted, and 7.08 percent or 2960.12 hectares are prohibited.
- 7.09 percent or 2952.19 hectares of the total area of Sumy are classified as basic conditions, 2.26 percent or 940.27 hectares are very unsuitable, 68.9 percent or 28692.13 hectares are unsuitable, 21.7 percent or 9058.43 hectares are limited suitable, and 0.03 percent or 11.48 hectares are suitable covered.

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