Natural rehabilitation potential in two distinct mining areas in Mongolia

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Abstract. Soil erosion in Mongolia has intensified, and the general level of soil fertility has decreased. The effects of global warming, and human activities such as grazing pastureland, mining operation, intensification of agriculture, urbanization, and road damage are the main causes of soil cover degradation. Due to the ecosystem characteristics of the geographical landlocked location within continental harsh, arid climatic conditions, there is clearly a different identification requirement in rehabilitation potential of mining areas. So, it is necessary to dig in to differentiate the possible rehabilitation characteristics on the most suitable ecosystems. And discrimination of the potentiality by the ecosystem and location makes how to achieve optimized mining rehabilitation results.

In this work, the focus is to concentrate on the natural healing process and weigh into potentiality using pyramid concept [1]. Study area and soil characteristics are considered on 2 distinct mining areas located in 2 different ecozones of Mongolian, one is in sub northern area, Ecozone III, which covers both sandy Katsanoses soil and gravelly sandy kastanozem soil. The other comparison study area is Ecozone VI, which within the desert zone the soil specially forms in gravelly and sandy features, and the vegetation becomes scarce with its both species and biomass due to its hot, dry characteristics. Kastanozem soil has more fertile components and thicker humus layer than the desert gravelly and sandy features. Natural features consist of climatological features (precipitation, temperature, wind), soil types and vegetation index data were collected and analyzed using ArcGIS software. These mining areas followed up with verification areas weighted in Khuvsgul and Southgobi areas appointed 180 and 120 points respectively. However, the potential scores on rehabilitation expenses explain active regions that the chance of adjustable value on those planned rehabilitation budget, where sustaining the soil rehabilitation stick into long term natural healing process.

These concludes that the pyramid concept should be applied to the other areas of Mongolian mining sites to enable natural rehabilitation potentiality into long term, sustainable mining rehabilitation plan.

Keywords: Natural rehabilitation, Rehabilitation potential, Mining potentiality, Sustainable mining

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1 Introduction

The mining sector is a major part of Mongolia's economy and an important source of economic growth, representing almost 24% of the country's GDP and about 90% of the total exports [2]. Coal is the most important raw material, with about 300 known coal deposits in the country, and coal resources of about 150 B tons. In 2022, Mongolia produced around 32 M tons of coal [3].

It is well documented that there are significant environmental impacts associated with coals mining and the use of coal, including issues such as land use, waste management, water, soil and air pollution. Open pit mining effects the landscape, which naturally diminishes the value of the surrounding natural environment. The land area is used for mining until it can be rehabilitated. Generally, rehabilitation of disturbed land does not match the original use. Surface mining removes existing vegetation, destroys natural soils, changes current land use, and to some extent permanently alters the general topography of the mining area. Removal of soil and rock overburden covering coal deposits can result in burial and loss of topsoil, exposing parent material and creating large barren wastelands. Soil disturbance and associated compaction create conditions that promote erosion [4].

In general, the aspect of rehabilitation in (coal) mining areas is becoming more and more important in the Mongolian society.

1.1 Aim of the work

In this paper, a model is presented to evaluate the (natural) rehabilitation potential of two regions. The model is based on the concept pyramid from Knippertz (2005). The overall goal of the concept pyramid is the development of a specific rehabilitation concept. To this end, the first step is to consider the relevant influencing factors, which are shown in three boxes at the base of the pyramid. In addition to the socio-economic factors, such as existing geotechniques, know-how or legislation, these are factors that are predetermined by the specific mining product. They are based on the type of mining or other characteristics, such as erosion and heavy metals. In this work, however, the focus is mainly on the natural influencing factors, whereby in particular the aspects of climate, soil and vegetation are considered.

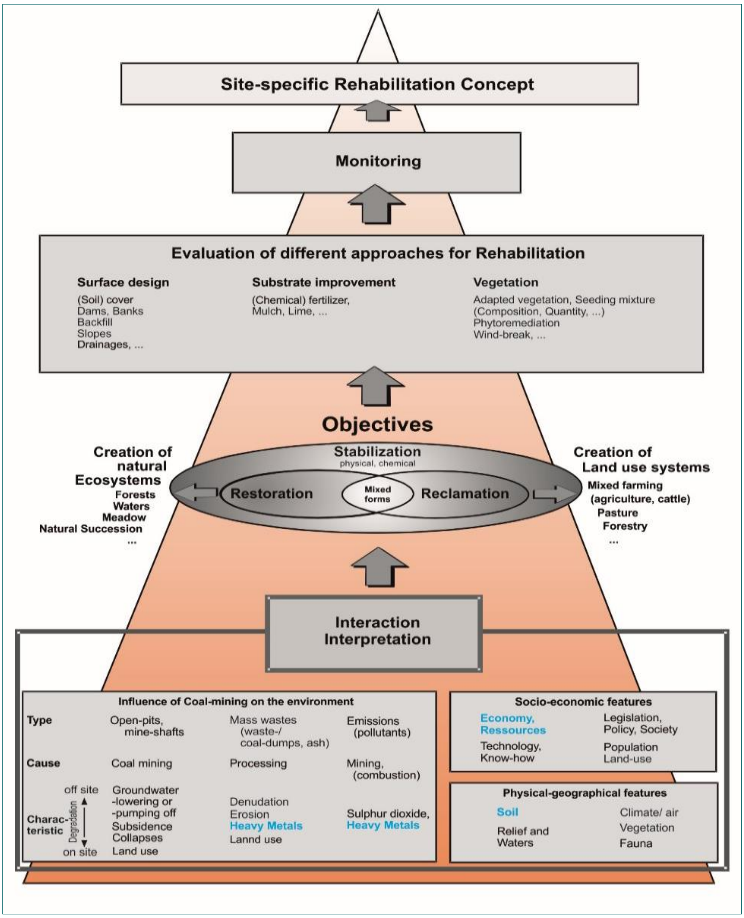


Fig 1. Concept pyramide [1]

All the above factors interact and lead to a definition of the rehabilitation goal. This can be restoration, reclamation, or stabilization. In the context of this thesis, rehabilitation describes all possible (environmental) goals associated with the use of geotechnical measures [5]. Restoration pursues the creation of natural ecosystems, while reclamation describes the creation of different land use systems.

After the definition of the rehabilitation goal [5], different measures can be derived, which finally, together with the necessary monitoring, lead to a site-specific rehabilitation concept.

1.2 Climate

Mongolia has an extreme continental climate with very cold winters and short, but warm summers, during which most precipitation falls. Rain is very rare in Mongolia, with annual averages from 200-350 mm in the North and only 100-200 mm or even less in the south.
Average temperatures over most of the country are below freezing from November through March and are above freezing in April and October.
Mongolia's weather is characterized by extreme variability and short-term unpredictability in the summer, and the multiyear averages conceal wide variations in precipitation, dates of frosts, and occurrences of blizzards and spring dust storms. Such weather poses severe challenges to human and livestock survival. Official statistics list less than 1% of the country as arable, 8 to 10% as forest, and the rest as pasture or desert.

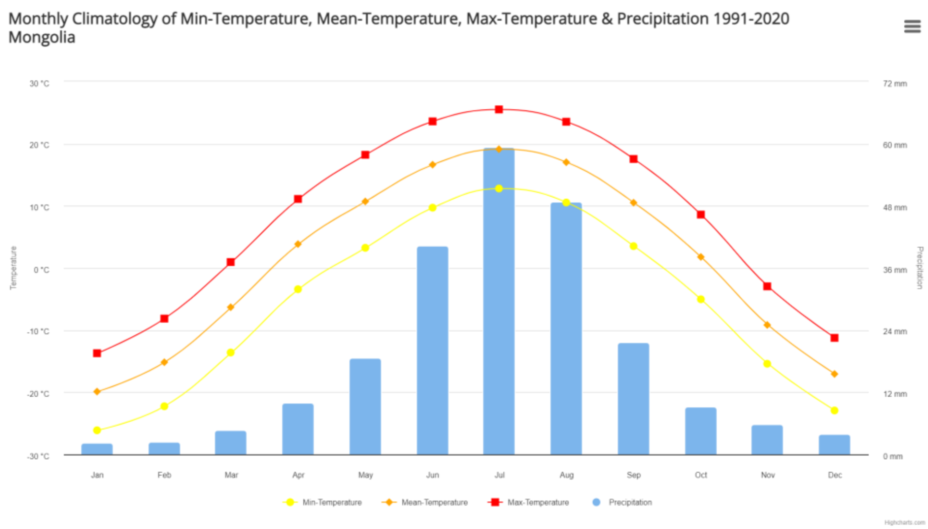


Fig 2. Mongolian climate mean indicators [6]

Fig. 2 shows a typical climate diagram with average values for Mongolia. The maximum to minimum temperature fluctuations with average values of -28 - +27 within an annual seasonal variance. The rainiest month is July with about 60 mm of precipitation.

1.3 Soil

Soil is considered the most important rehabilitation factor in many works. Due to its properties, soil can serve as a filter, buffer, and transformer for substances. Transferred to mining or a rehabilitation concept, soil serves as a cover material for barren land and as a foundation for plant growth, which in turn can curb erosion. Soil can absorb pollutants such as heavy metals.

The distribution of soil types in Mongolia is essentially based on latitude. Besides the geological parent substrate, the climate is the decisive soil-forming factor.
In the north of Mongolia, the soils of the Mountain Forest Steppe dominate. Most of this soil zone is Mountain Steppe. The most common soil is the Mountain Kastanozem soil. The thickness of the humus layer varies from 10 to 40 cm. The humus content in the upper layer of the mountain chestnut soil ranges from 1.5 to 4.5%. The texture of the soils is dominated by a sandy structure, with silty components. These soils are not suitable for cultivation and can be used as pasture [7].

The next zone to the south is the zone of dry steppe with Kastonozem soils. These Kastanozms are usually of a high quality. The thickness of the humus layer is around 30-40 cm, sometimes more than 50 cm, and the humus content is 3.5-4.5%. The predominant textures are loam, light clay and sand. Dark Chestanozems are important for agriculture because of their high nutrient content.
Finally, in the south of Mongolia, the soils of the desert steppe are found. Due to the low rainfall, strong winds and dry heat in this area, soil formation takes place under arid conditions. The general characteristics of the soil are well-defined layers, loamy and low in humus. The humus content of the Gobi brown earth reaches up to 0.3-0.8%.

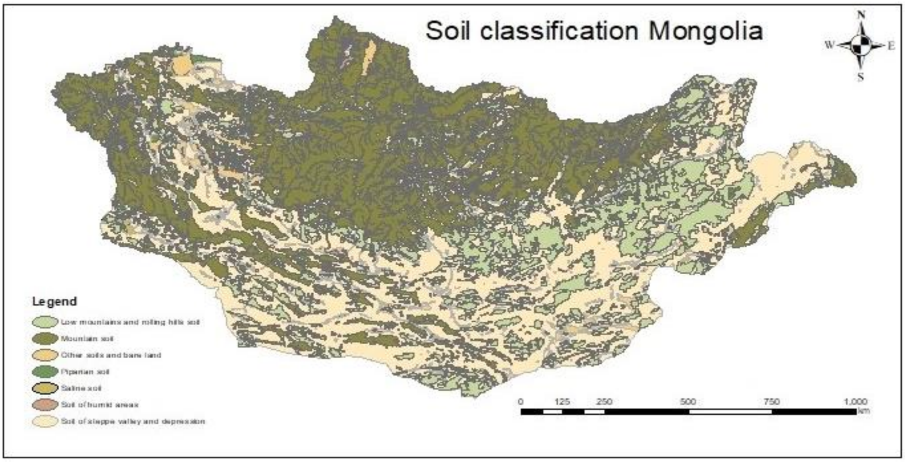


Fig 3. Soils of Mongolia [8]

2 Methodology

The potential of natural rehabilitation is selected with the most influencing criteria related to the ecosystem determinations. Furthermore, the publicly available Open data is used to determine national ecozone and its specification [8]. The ecozones discrimination relevant to the analysis of the rehabilitation potential is carried out here, that presented in chapter 3. Due to the restrictions mentioned, the analysis was time consuming for all the factors described in the Pyramide [1].

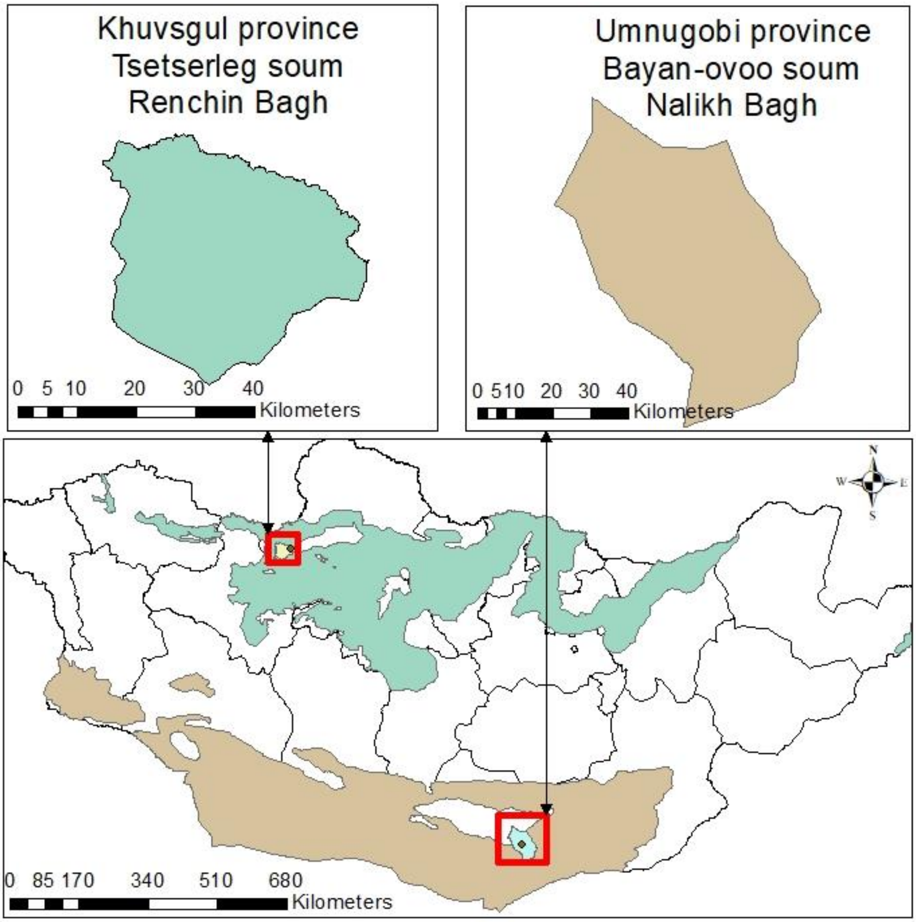


Fig 3. The verification area of the natural zones [9] Own representative)

In the development stage of the natural rehabilitation potential, verification procedures should have taken into consideration to make the methodology meets its intended values of the region’s specifications.

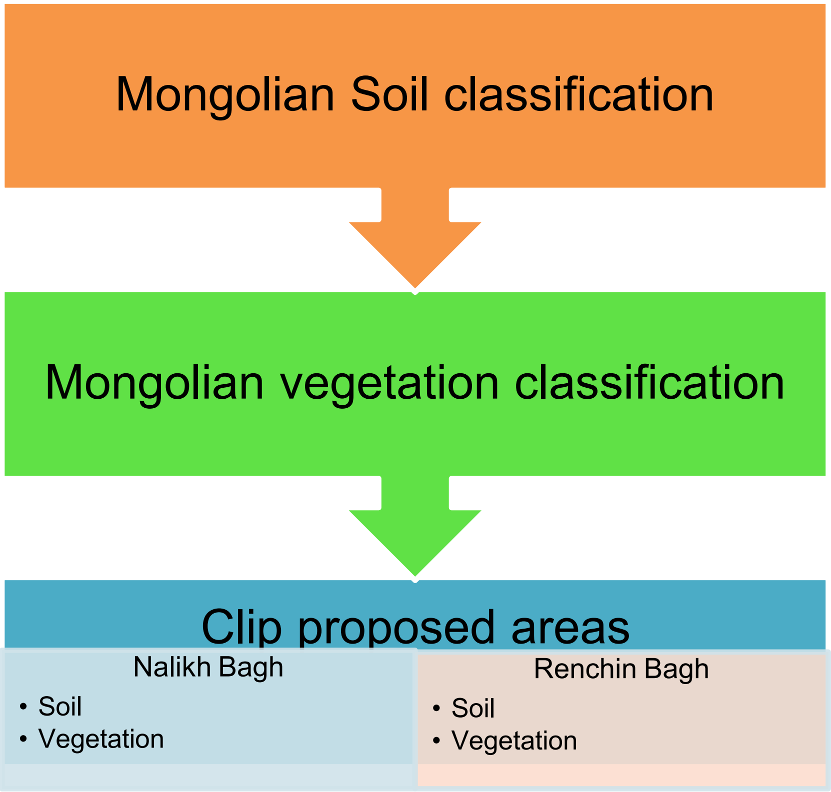


Fig 4. Study area – process scheme

3 Rating of the selected verification area

The rating of the study is also considered the main characteristics of degradation source of the mining, that is generally impacts in dot point. The degradation source of the mining is actually not impacting like moving along lines or distributing among fast moving over an area, such as the livestock pastureland deterioration or climate change impact on the land. Needless to say, the perception that grassland degradation is caused by climate change is quite common [10]. A comparative experimental study carried out in the steppes of Mongolia revealed that the intensive use of pastures leads to a decrease in crop productivity and a decline in useful plants, resulting in the deterioration of the root system [11]. On the other hand, with the introduction of appropriate methods of use, the vegetation cover will be restored, and the yield and fodder resources will increase accordingly.

Only it influences on accumulation of the point source pollution on the same location. Needless to say, rating is considered on dot point characteristics of mining rehabilitation potential.

When weighing the assessment, 100% of the maximum value will be given to the soil with the highest ph value with highest humus content and the highest plant growth within the favorable climate condition area. Whilst the 0% rating is prescribed of the minimum valued soil with the lowest qualified humus content with lowest degree of growth.

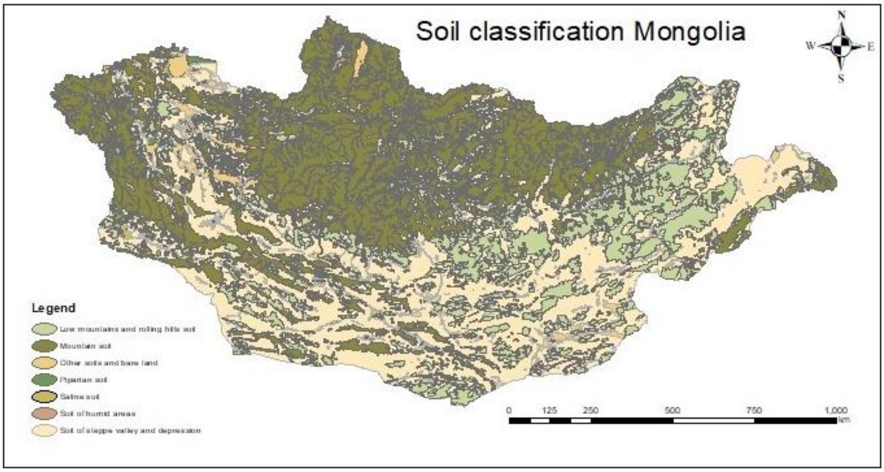


Fig 5. Mongolian soil types (own represetative [8])

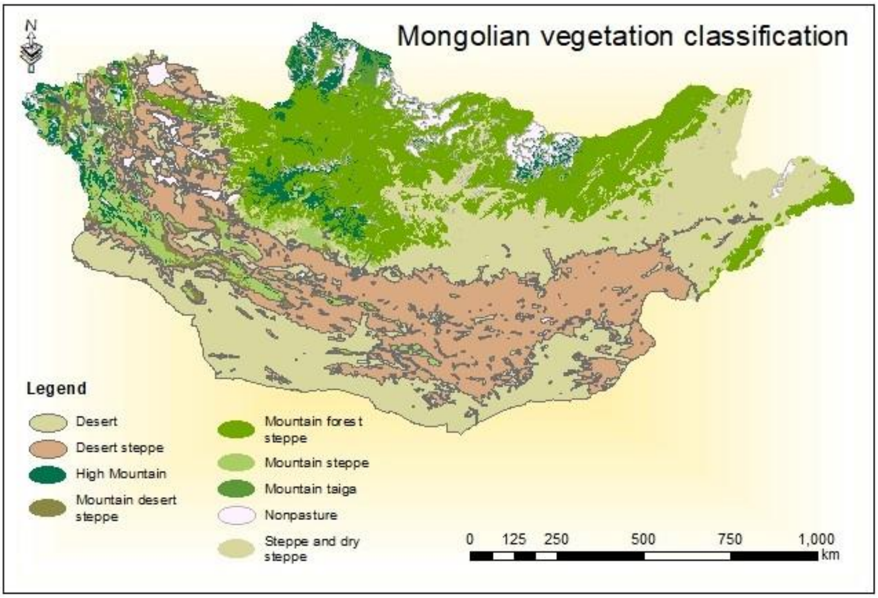
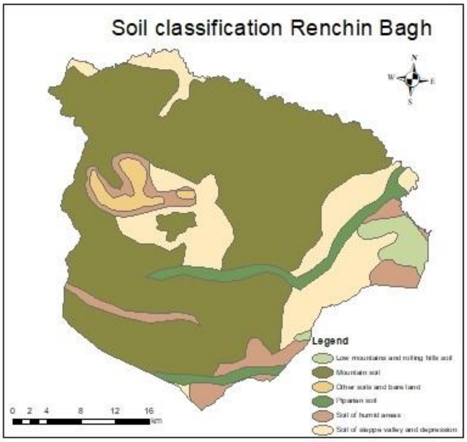
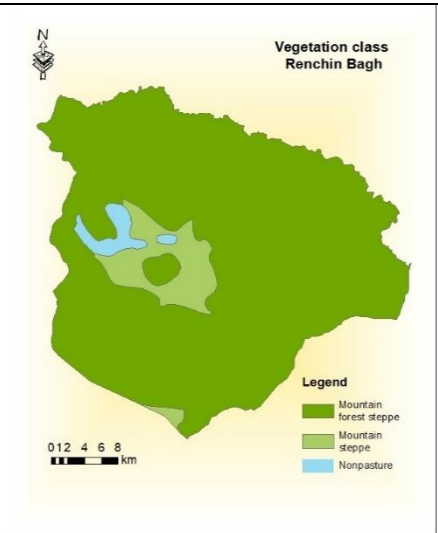


Fig 6. Mongolian vegetation types ([8] own representative)

It interprets that Mongolian vegetation types are much evenly distributed with its own respective unique climatology besides the natural location differences.



Soil classification



Vegetation classification

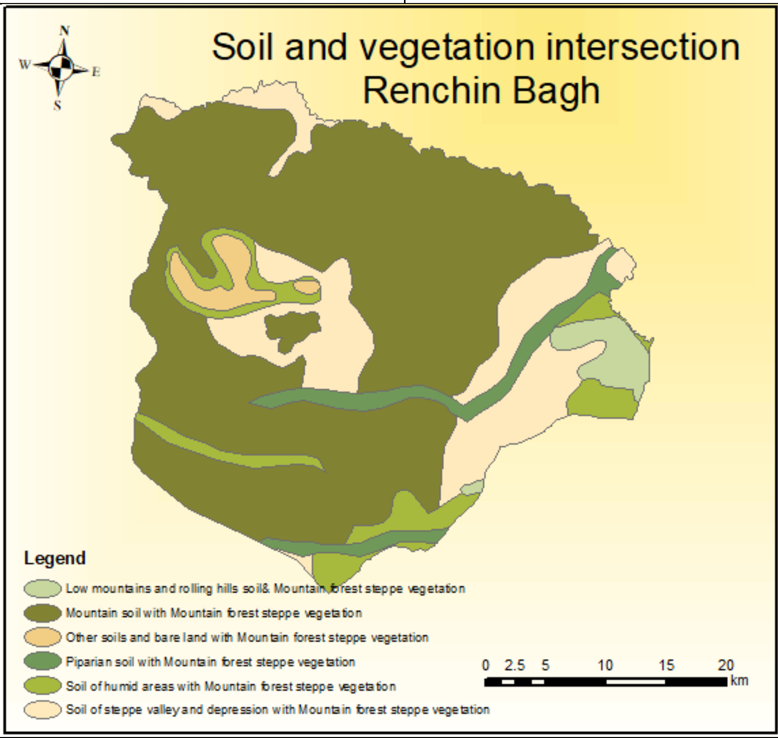


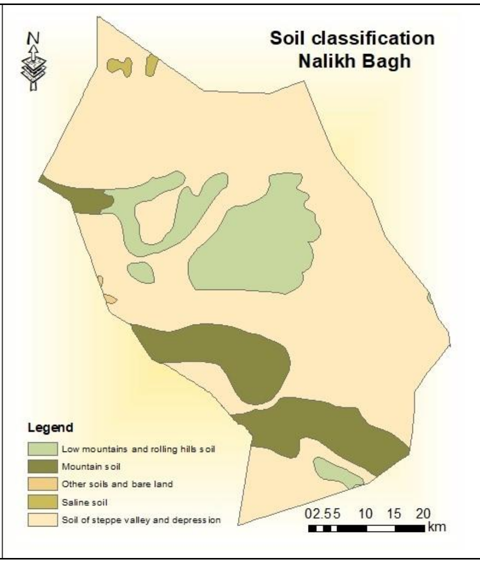
Fig 7. Soil and Vegetation potential amount, result of intersection

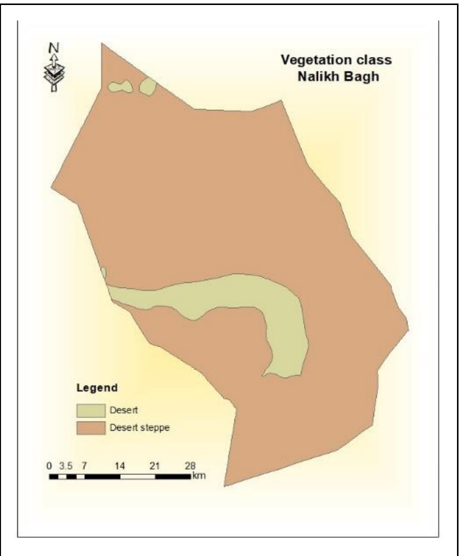
The the ArcGIS 10.8 version is used in this work, by utilizing the base data of the Mongolian soil and vegetation data and the base data of the both administration area of the Bagh and Soum boundaries are provided by the environmental information center [8] online source. The main vegetation and soil maps are clipped by the base map of chsosen Bagh areas from Soutern (Nalikh area of Umnugobi province, Mongolia) and the Northern (Renchin Bagh area of Khuvsgul province Mongolia).

Vegetation Data. These basic data of the vegetation is provided in shapefile by a Mngolian boundary, which is divided into polygon shapefiles by 21 types of vegetation groups such as river valley meadow vegetation of the Northern part of Mongolia, or desert steppe in flat area of the Southern part of Mongolia.

Soil data. Soil types of Mongolian boundary is provided in polygon shapefile. The soil types are devided in 7 types of soil that distributed at all types of a certain ecosystems.

Geoprocessing. Data clipping is used on both areas by the Bagh boundarsis with its classifications. That classifications are categorised by color symbologies at each soil and vegetation types. Then, the color symbolozed areas being overlapped by its area with their parallel soil and vegetations, using intersection of geoprocessing tool.





Soil classification	Vegetation classification

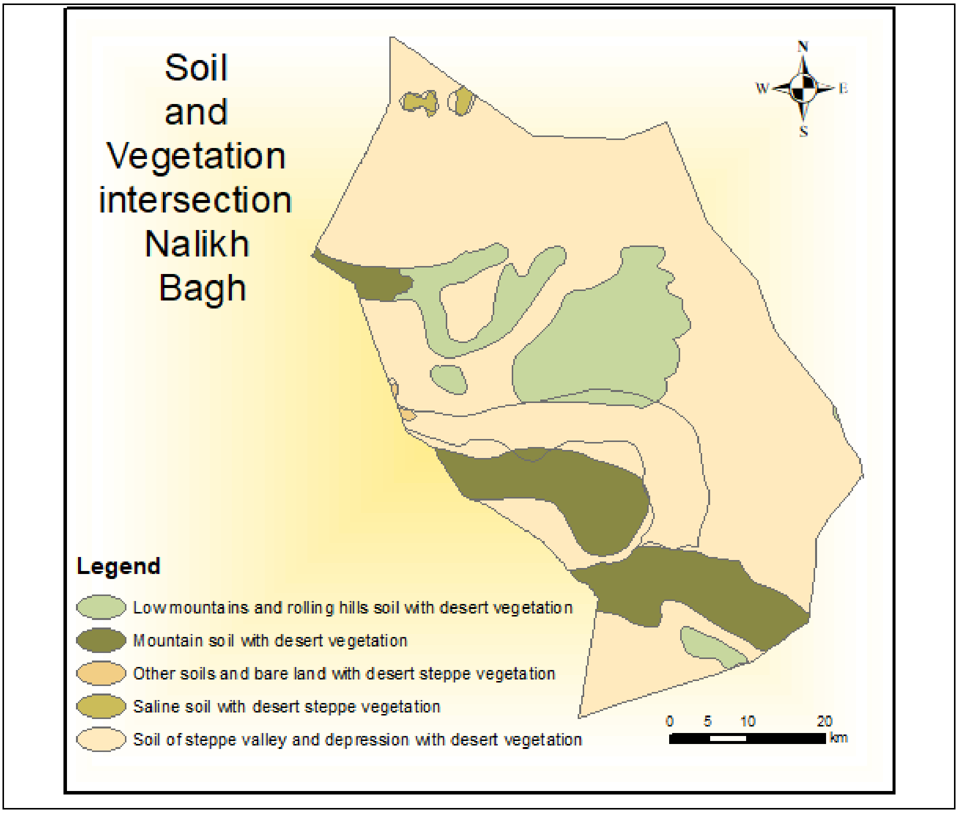


Fig 8. Soil and Vegetation potential result of intersection

Table 1. Verification area of the study area

Weighting Factors	Forest steppe zone III	Desert eco-logical zone VI	Verfication Renchin Bagh	Verification Nalikh Bagh	Reference
Climate	40-50	40-50	55	50	80
soils	60-70	30-40	70	40	70
Vegetation	40-50	30-40	55	30	80
Rehabilitation potential	155	115	180	120	230

Verifying with the critical ratings utilizing identical factors such as climate conditions (the wind, temperature, precipitation), soil (pH, humus, Carbonate ion (CO_3^{2-})), and vegetation (scarcity, biomass) respectively have provided.
Within the verification, the grades are low (0-30), middle (31-60) and good (61-90) soil quality is calculated towards the seven types of soils.

In regard to the vegetation, the gradings are counted as low (0-30), middle (31-60) and good (61-90) vegetation quality towards the 21 types of soils.

4 Discussion

The weighted intersection of the individual factors aim to develop a general analysis with the possibility of adapting the model to mining locations. The basis of the analysis is the consideration of three factors, that requires supporting data in need of data certainty.

To present the results, these three factors were assessed across Mongolian northern ecozone and southern desert ecozone. Mining and exploration activities taking place on both these 2 ecozones, besides that the biggest deposts lies in southern ecozone, such as Oyu tolgoi, Tavantolgoi, Southgobi sands etc.

Regarding the factors taken into the research work, the other factors considered in the concept pyramide should be included to calculate much detailed result of the progressive rehabilitation potentiality. Such as social data of the community related status, where livestock of the local area takes important factor for the pastureland and rehabilitation progress of the study area.

5 Benefits of the Natural rehabilitation potential

It, also known as ecological restoration or ecosystem restoration, offers several advantages. Here are some key benefits of natural potential rehabilitation:

Soil Stabilization and Erosion Control: Rehabilitating ecosystems helps stabilize soil and control erosion. The restoration of vegetation cover and root systems aids in preventing soil erosion and loss, particularly in areas prone to land degradation, such as degraded forests, deforested lands, or areas affected by mining or agriculture [12]. This helps to retain soil fertility, prevent sedimentation in water bodies, and mitigate the impacts of erosion on surrounding ecosystems.

Climate Change Mitigation: Ecological restoration contributes to climate change mitigation efforts. Restored ecosystems act as carbon sinks, sequestering carbon dioxide from the atmosphere through enhanced plant growth and soil carbon storage. This helps to reduce greenhouse gas emissions and mitigate the impacts of climate change.

Water Resource Management: Natural potential rehabilitation can have positive effects on water resources. Restored ecosystems contribute to improved water quality by filtering pollutants, reducing sedimentation, and regulating water flow [11]. Restored wetlands, for example, help in water retention, flood control, and groundwater recharge.

Cultural and Aesthetic Value: Restoring ecosystems has cultural and aesthetic benefits. Rehabilitated natural areas provide opportunities for recreation, education, and research, allowing people to reconnect with nature and appreciate its beauty. Restored landscapes can also have cultural significance, preserving traditional practices and enhancing the sense of place and identity for local communities.

Socio-economic Benefits: Natural potential rehabilitation can bring socio-economic benefits to local communities. It can create employment opportunities through restoration projects, eco-tourism, and the sustainable use of restored ecosystems. Restored habitats can also support sustainable agriculture, forestry, and other livelihood activities.

Overall, natural potential rehabilitation offers a holistic approach to environmental conservation and sustainable development, promoting the recovery and resilience of ecosystems while providing numerous ecological, social, and economic benefits.

6 Conclusion

Socio-economic is also an important area, and legislation is the other important part of the rehabilitation due to the timing.

There is a quiet a detailed standards and procedures in place that the different types of mining should plan and implement of. While the specifics of existing soil of those different types of mining, doesn't really considered in this work. For instance, the rehabilitation standards were applied on the general requirements of the mining, such as:

- MNS 5916:2008 - Environment. Requirements for fertile soil removal and its temporary storage during the earth excavation.
- MNS 5918:2008 - Environment. Re-vegetation of destroyed land. General technical requirements,
- MNS 5850:2008 - Soil quality. Maximum acceptable concentration of soil pollutants elements and substances.
- Rehabilitation cost estimate guidelines - Decree № 07-114 issued by Minister, Ministry of Environment and Tourism.

The Ecozone of the Northern area dominates forest-steppe soil, where climate and population density occur much colder and higher than the south area.

It is economically and sustainable beneficial to utilize natural rehabilitation methods instead of forcing mining rehabilitation by scattering seeds and irrigating. By the ecosystem functionality, the Natural potential rehabilitation aims to restore the natural functions and processes of ecosystems. By restoring degraded areas to their original state or improving their ecological condition, it enhances the overall functionality of ecosystems. This includes restoring nutrient cycling, water filtration, pollination, and habitat provision, leading to improved ecosystem services [13].

On the other hand, by the biodiversity conservation side, ecological restoration plays a crucial role in preserving and promoting biodiversity. By creating or restoring suitable habitats, it supports the recovery of native plant and animal species, including endangered or threatened species. Restored ecosystems can provide critical corridors for wildlife movement and contribute to the conservation of regional biodiversity.

In my perspective, global warming impacts particularly on land degradation, making matters worse there is rising livestock foot deterioration due to increasing livestock number. However, mining dot point degradation takes considerably low amount of overall land degradation. Therefore, this mining rehabilitation method really should use this existing natural rehabilitation potentiality.

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