

Soil mapping of Mongolia

Dr. Ochirbat BATKHISHIG

Sodnomdarjaa IDERJAVHKLHAN

Soil Laboratory

Institute Geography

Mongolian Academy of Sciences

email: batkhishig@gmail.com



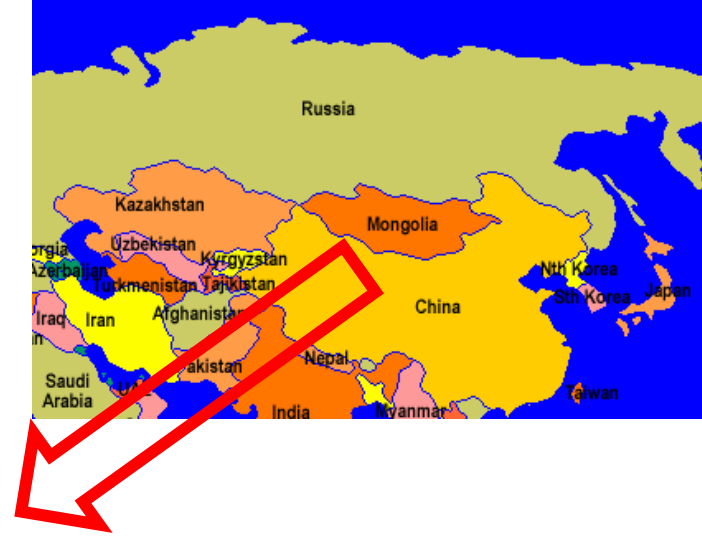
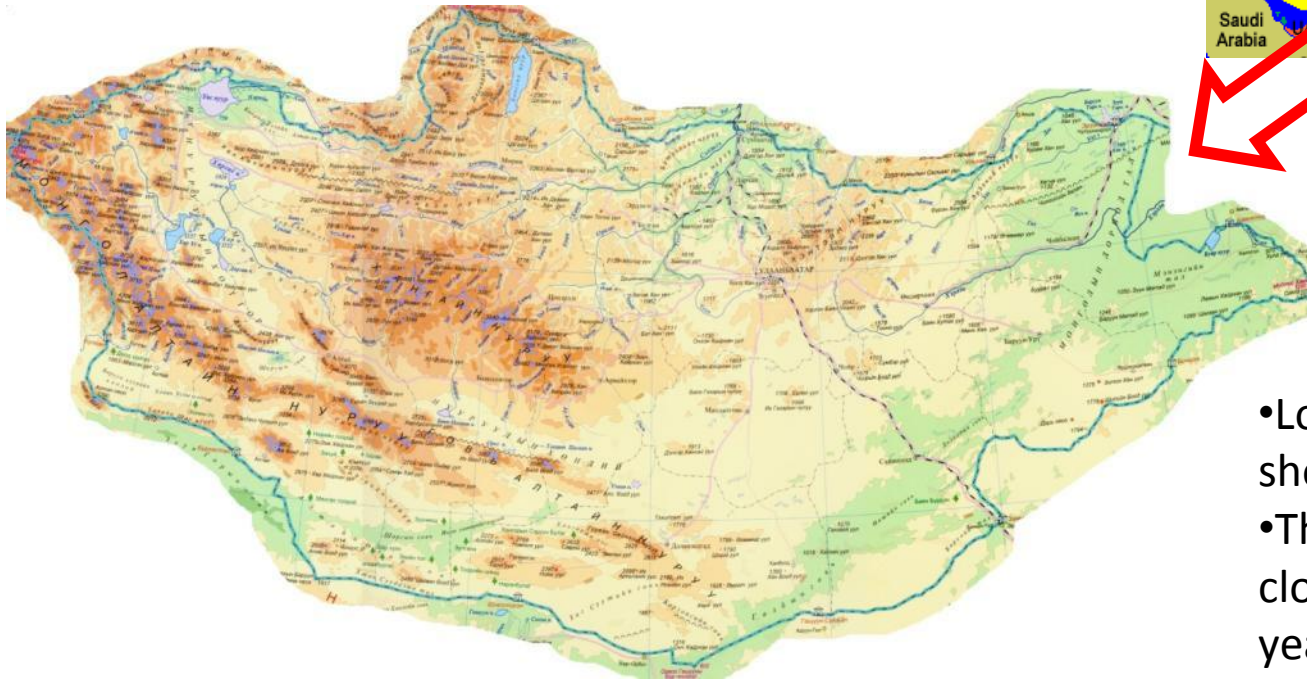
Outlines

- Introduction Mongolia, Environmental problems
- Soil database of Mongolia
- Case study Soil mapping of Kharaa river basin
Central Mongolia
- Soil mapping of Mongolia

Mongolia is Central Asian country, extra-continental climate conditions .

Territory 1565 sq.km , Population 2.8 mln

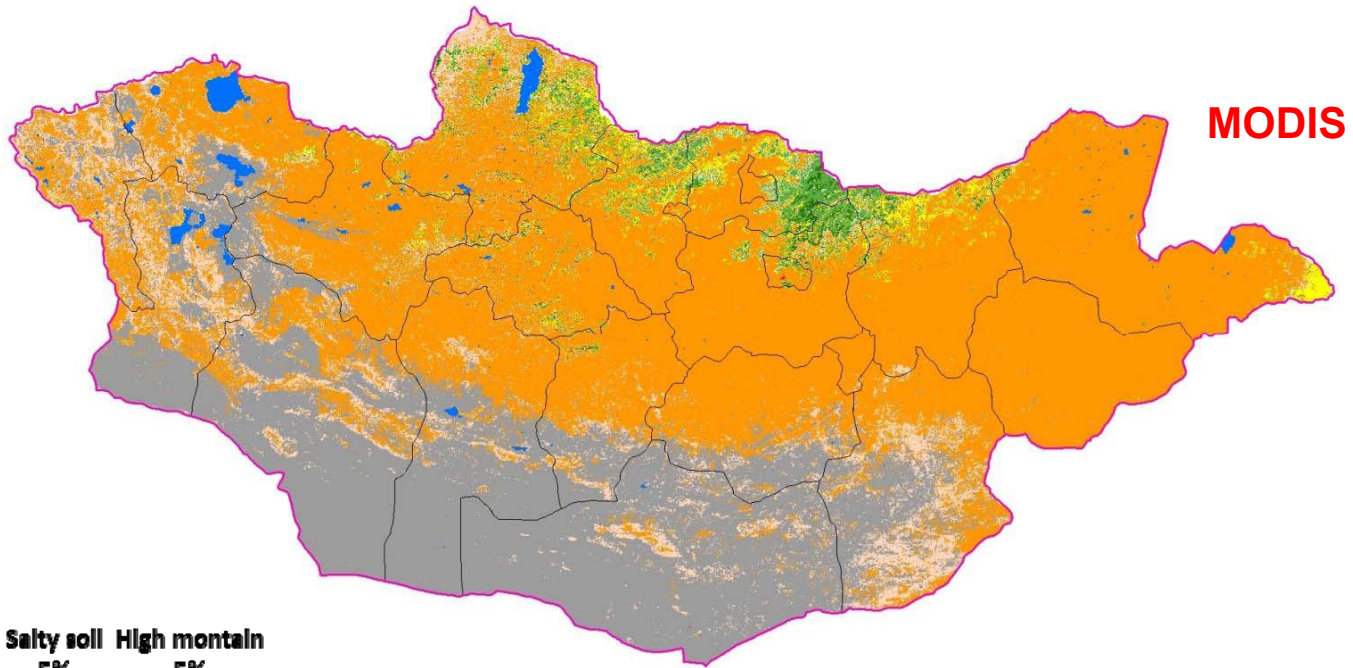
Average elevation is 1580 meter a.s.l.



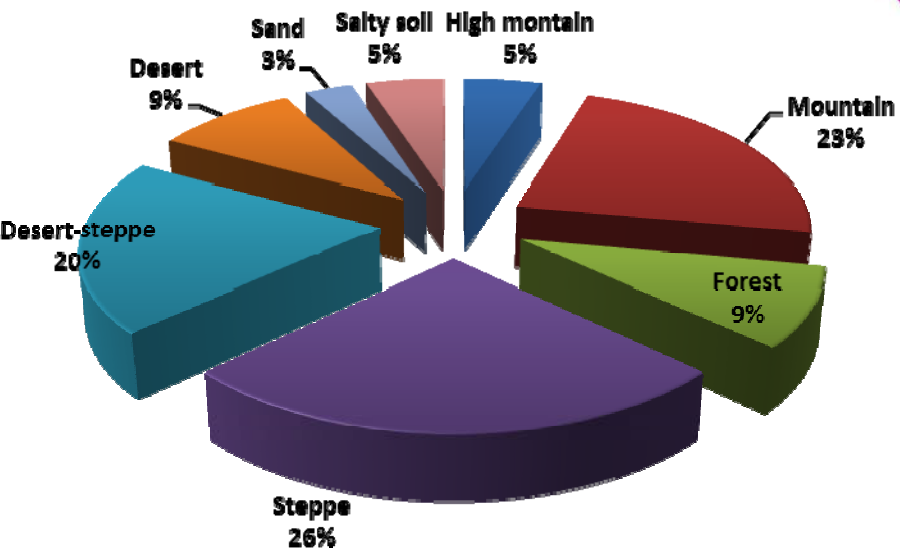
- Long, cold winters and short summers.
- The country averages 257 cloudless sunny days a year.

•Precipitation is highest in the north (average of 200 to 350 mm) and lowest in the south 100 -200 mm annually. The extreme south is the Gobi, some regions of which receive no precipitation at all in most years.

Land cover of Mongolia



MODIS



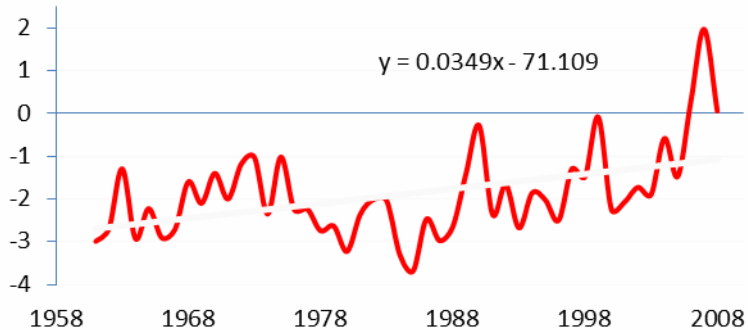
LANDSAT

Environmental Problems

- Climate warming in Mongolia, becoming very serious
 - Water recourse shortage
 - Permafrost melt
 - Desertification
- Overgrazing as human impact on pasture land
 - Grazing land is 72.1 % of all territory
- Steppe and forest ecosystems of Mongolia significantly drying last decades

Climate change

Air temperature, C (UB station)



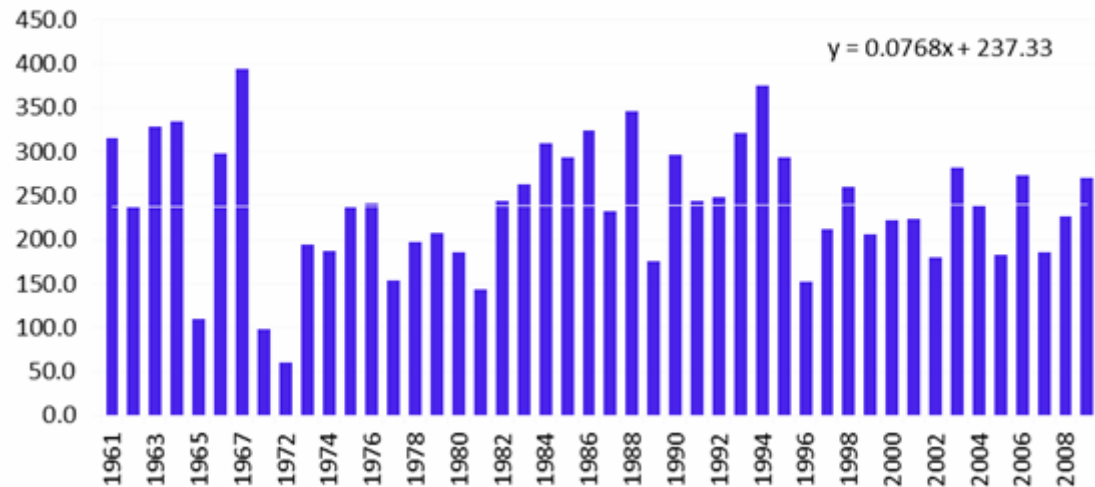
Last 70 years air temperature increased by **2.1°C** (Ulaanbaatar)

•This is 2 - 3 times more than World average

World is 0.6-0.7°C

Annual precipitation ranges **225.5-269.2** mm, increased slightly by 10 mm

Precipitation, mm (UB station)





Permafrost melting

Soil properties decline



Melted pingos

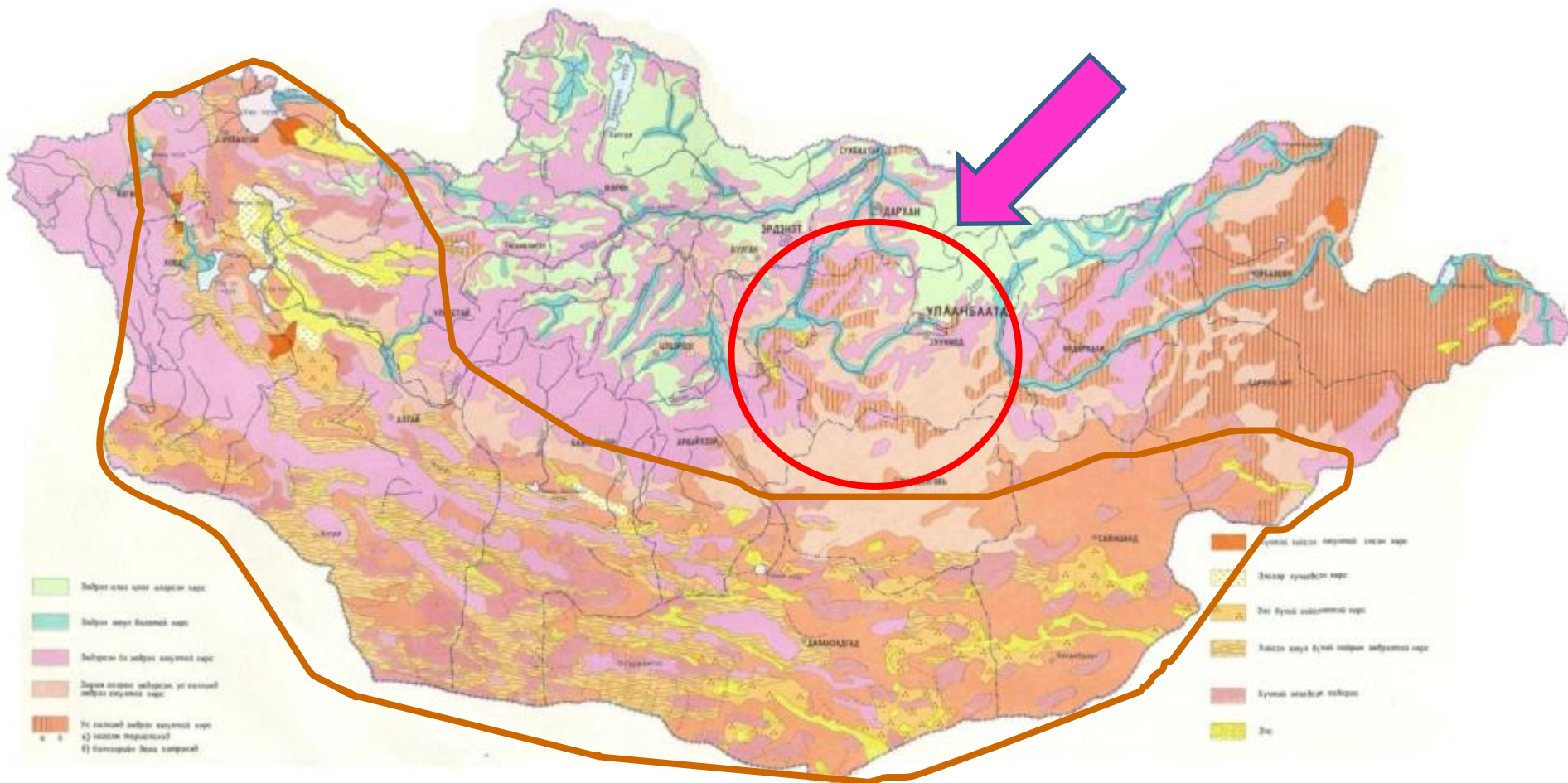


Soil drying



Wetland decline

Most soil degraded in Central Mongolia,
where more human impact



44,5 % or 700 thousand km² area occupied by arid land or Gobi desert vulnerable for soil degradation

Soil database of Mongolia

Soil profile data

Hard copy (More than 10 000 soil profile data)

Digital format – Using Access, Excel

Soil map data

Soil maps of Mongolia , scale 1 : 1 000 000, 1 : 2 500 000,
Soil map of different regions, scale 1 : 100 000, 1 : 200 000

Soil publications (mostly in Mongolian and Russian lang.)

Books

Articles

Reports

Soil map database of Mongolia

Before 2000

Most soil maps on hardcopy

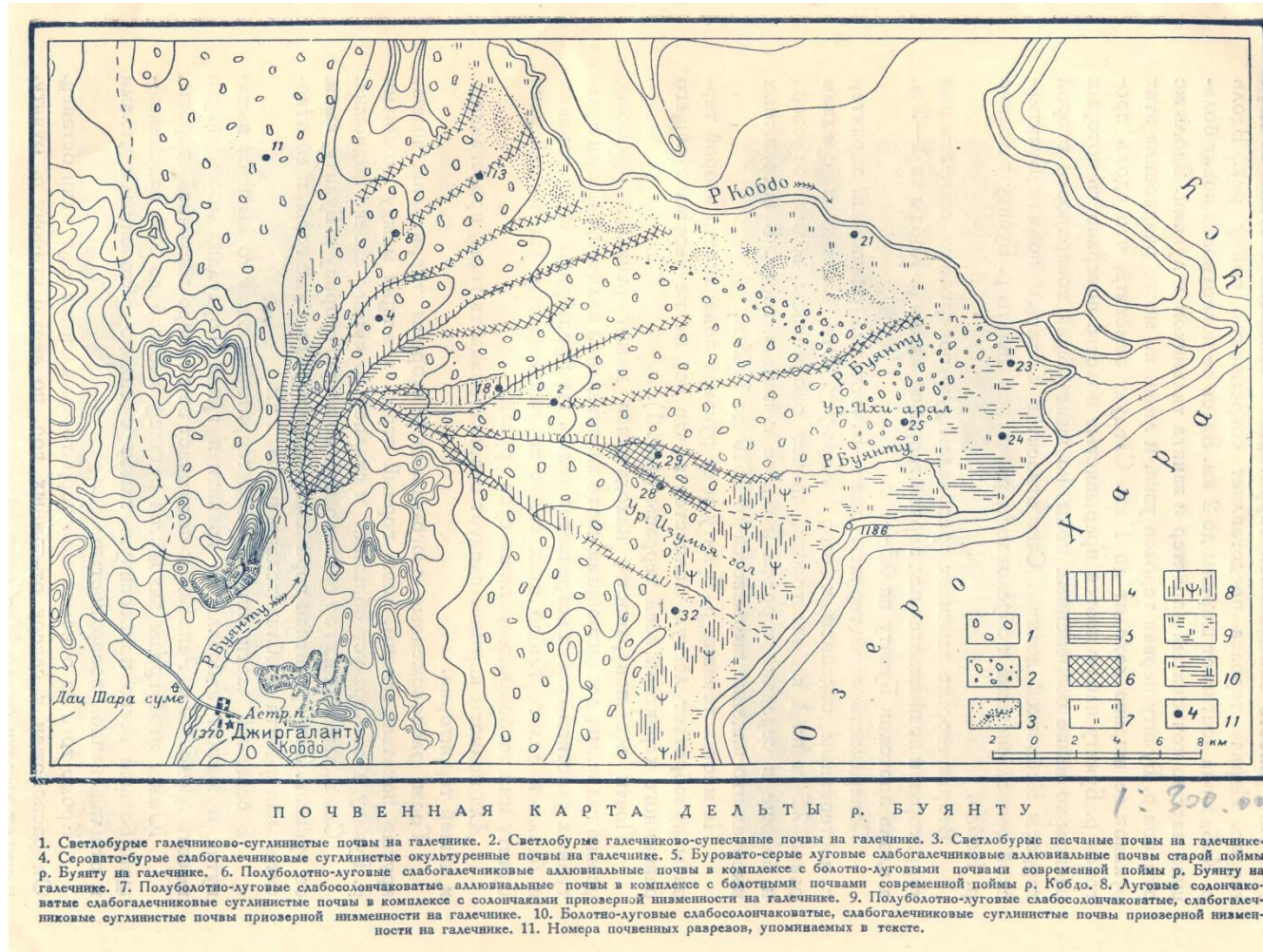
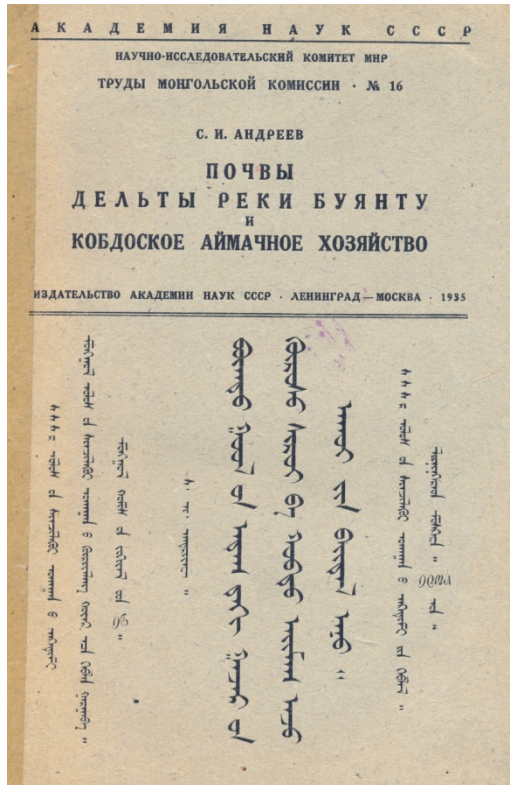
- Besspalov N D, Soil map of Mongolia, 1951. Scale 1 : 5 000 000
- Andreev S I, Soil of Buyant river delta area, 1936
- Land Authority Office data 1970-1980
 - Soil map 1 : 200 000,
- Soil map of Mongolia, scale 1:2 500 000, 1980
- **Soil map of Mongolia, scale 1 : 1 000 000. 1981**
 - Using air photos

After 2000

Digital soil maps

Soil maps of different regions of Mongolia

Andreev S I, Soil of Buyant river delta area, 1936



Map quality

1 : 200 000 (1977)



1 : 1 000 000 (1981) + 1 : 200 000 (1977)



1 : 1 000 000 scale soil map better resolution

Soil data before 2000

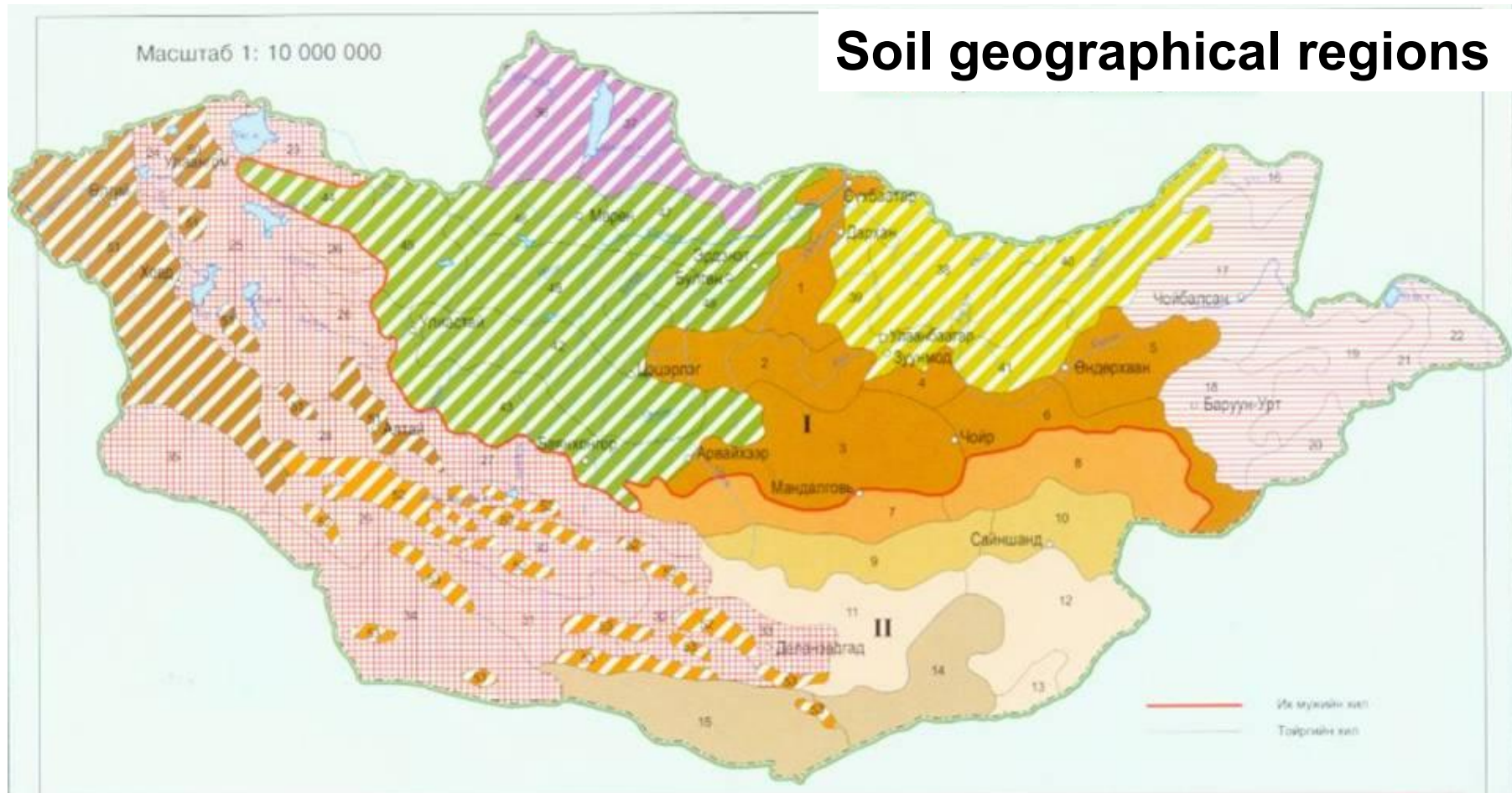
Data available

- Morphological characteristics
- Soil horizon thickness
- General chemical properties
 - Organic content, pH, Calcium carbonate, exchangeable Ca, Mg, texture

Data lack

- No coordinate location
- (example: west to soum center 10 km)
- Not data about water physical properties
 - Only soil texture (Russian classification, Kachinskii)
 - Not much data about soil stone gravel content
- Soil fine material less than 1 mm (Russian)
- International standard is less than 2 mm.

Soil geographical regions



Case study Kharaa river watershed area (2008)

Total 26 soil profiles
100 soil samples



Used data for soil mapping

Гарчиг

Абтгүүл

Судалгааны аргазүй, зарчим

**Судалгаанд ашиглаж буй
мэдээ**

Мэдээ боловсруулалт

Судалгааны үр дүн

Судалгаанд тулгамдаж байгаа
асуудлууд

Цаашид хийгдэх болон
ирээдүйд хийгдэж болох
ажлууд

Outline

Background

Scientific methods,
approaches

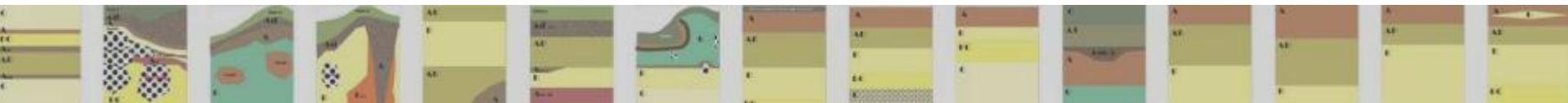
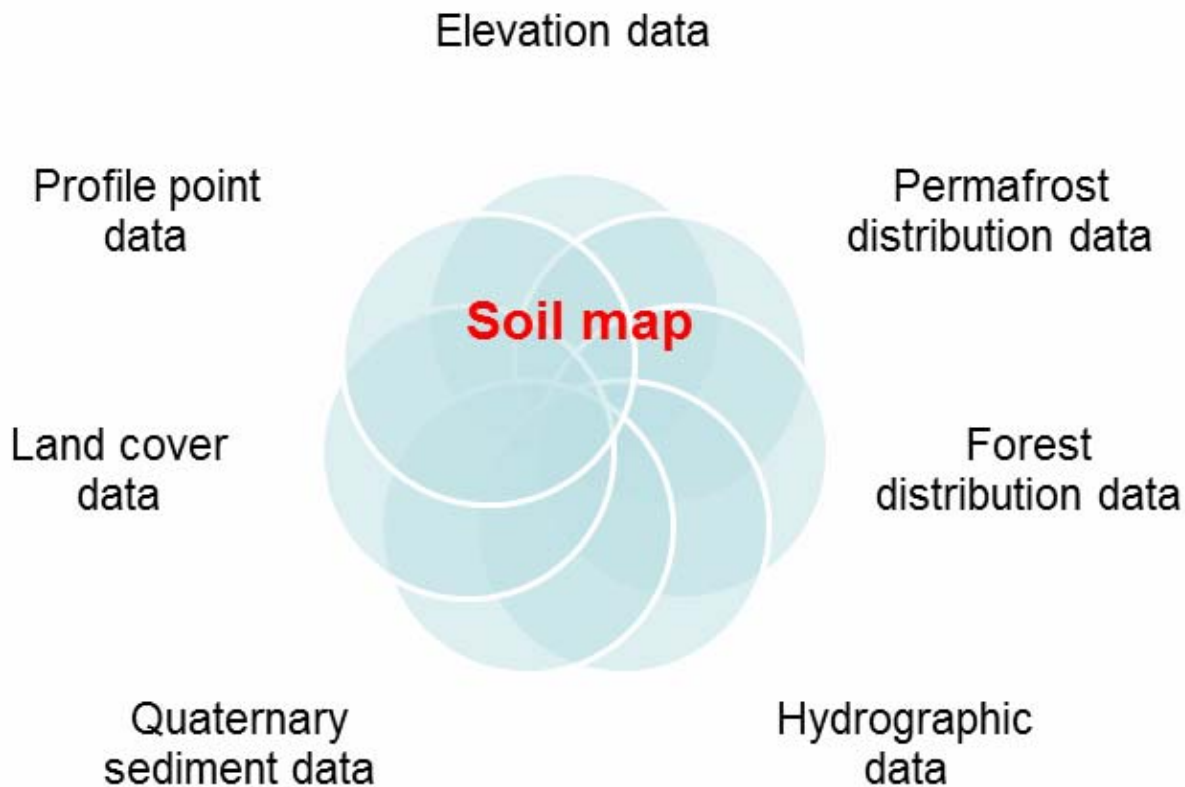
Data

Data preprocessing

Results

Problems for Soil study

Outlook (Future works)



(Scheme) Methods of soil mapping in the Kharaa basin

Гарчиг
Аборт
Судалгааны аргазүй, зарчим
Судалгаанд ашиглаж буй
мэдээ
Мэдээ боловсруулалт
Судалгааны үр дүн
Судалгаанд тулгамдаж байгаа
асуудлууд
Цаашид хийгдэх болон
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ажлууд

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Background

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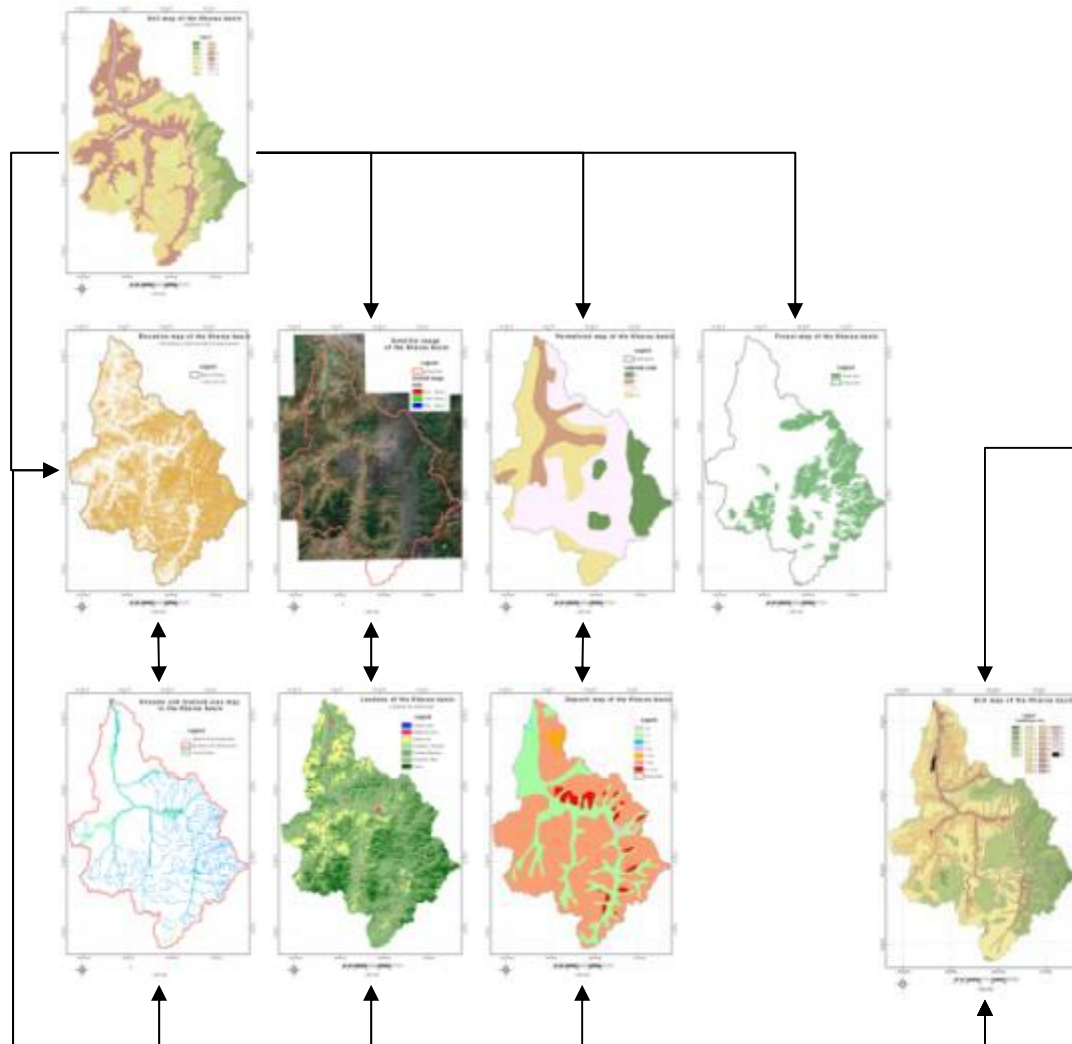
Results

Problems for Soil study

Outlook (Future works)

Level 1

Level 2



88 Зүсэлт

408 үе давхарга

3264 ширхэг тоон мэдээ

(Humus, N, pH,
Exchangable Cations,
Sand, Silt, Clay, Bulk
density)

Хөрсний
зүсэлтийн
мэдээ

Урьдчилсан
хөрсний зураг

10 May 2008

Field measurement	Methods	Quantities
Soil profile morphological Sampling.	Selected a specific horizons of profiles /lower boundary/	120 Horizons, 26 profiles
Temperature	Soil /active layer/ (C ⁰) temperature measuring. In the air and depths : 1, 5, 10, 20, 30, 40 cm	100 samples 104 definition horizons temperature
Moisture	Soil moisture (%) measurement by TDR. In the depths 1, 5, 10, 20, 30 cm	78 definition of horizons moisture
Density	Soil density (kg/cm ³) measurement by penetrometer In the depths 5, 10, 20, 30, 50	78 definition of horizons density
Infiltration rate	Infiltration rate (cm/hour) by single ring infiltrometer.	26 profiles
Water holding capacity	Soil water holding capacity measurement In the depths 5, 10, 20, 30, 50cm	2 cycles at 50 horizons
Soil name (Mongolian, FAO)	Determination of soil name using field characteristics and FAO field keys	26 profiles

PROFILE DESCRIPTION

Profile No. MM-01 /Shavart/

Date : 2008-09-17
 Time : 15-00
 Location : N 47° 10' 13.2"
 E 106° 49' 44.9"
 Elevation : 1346 meter a.s.l.

Geomorphic information:

Landscape : Aside
 Natural zone : Forest
 Strata : North lower slope
 Surface gradient : 8 (degree)

Physical status:

Surface note:

Surface stones: 0%

Canopy cover : 60-70 %

Dominant species: *Betula sp*, *Larix sibirica*, *Populus sp*, *bush sp*, *forbs sp*

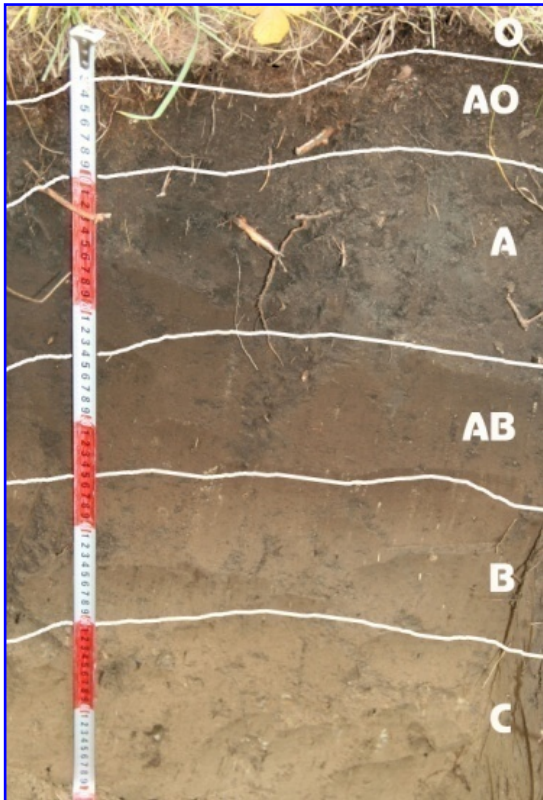
Soil type: Mountain forest dark-colored soils /Mollic Umbrisols/



Depth (cm)	Moisture (% , VWC)	Temperature (°C)	Penetration resistance (kg/cm ²)
Air			
5	13	8.7	0.5
10			
20	14	7.2	1.75
30			
40	15	6.7	3
50			5

Morphological description

Soil type: Mountain forest dark-colored soils /Mollic Umbrisols/



- | | | |
|-----------|--------------|--|
| O | 0-3 | very dark gray (10YR 3/1), no mottle, moist water state, clay loamy, sub-angular structure, many very fine to medium roots, abrupt smooth boundary |
| AO | 3-10 | very dark gray (10YR 3/1), mottled, moist water state, clay loamy, sub-angular structure, many very fine to medium roots, abrupt smooth boundary |
| A | 10-24 | black (10YR 2/1), moist water state, clay loam, angular structure, very fine to medium roots, abrupt smooth boundary |
| AB | 24-35 | Dark reddish brown (5YR 3/3), moist water state, clay loam, sub angular structure, abrupt smooth boundary |
| B | 35-50 | Light Olive brown (2.5Y 5/3), moist water state, clay loam, angular structure, abrupt smooth boundary, stone 20-30% |
| C | 50-80 | Light Olive brown (2.5Y 5/3), wet water state, clay loam, sub -angular structure, abrupt smooth boundary, stone 20-30% |

Laboratory analysis	Methods	Quantity
Preparation of soil sampling	Air dried soil samples, then sieved by 2 mm sieve.	100 samples
Organic Carbon	Tyurin	80 samples
Nitrogen	Kyeldal	80 samples
Exchangeable Ca, Mg,Na,K (meq/100g)	1 M NH ₄ OAc Spectrophotometer	80 samples
Available elements (mg/100g) P ₂ O ₅ , K ₂ O	1% NH ₄ CO ₃ Spectrophotometer	80 samples
pH (H ₂ O)	1 : 2.5	100 samples
CaCO ₃ (%)	Volumetric	100 samples
Particle size	Pipette	100 samples
Bulk density	Cylinder	80 samples (x3)
Particle density	Picnometer	80 samples
Porosity	Calculation	80 samples
Field capacity	Gravimetric method	80 samples
Permanent wilting point	Gravimetric method	80 samples
Saturation water content	Calculation	80 samples

Soil data converting to the constant horizons



Original data		Constant layers, cm			Corresponding		Weighted mean
MM-01	Organic matter, %	Lower	interval	depth	depth	Organic matter, %	Organic matter, %
0-10	11.60	10	0-10	10	10	11.60	11.6
10-24	6.91	30	10-30	20	14	6.91	5.8
24-35	3.14				6	3.14	
35-50	0.68	50	30-50	20	5	3.14	1.3
					15	0.68	
		70	50-70	20			
		100	70-100	20			
		A50	0-50	50			5.1

For the further soil data processing and modeling purpose, soil horizon dates converted to the 0-10, 10-30, 30-50, 50-70, 70-100, 0-50 cm depth.

Used weighted mean

$$\frac{\sum_{i=1}^n w_i x_i}{\sum_{i=1}^n w_i} = \frac{w_1 x_1 + w_2 x_2 + \dots + w_n x_n}{w_1 + w_2 + \dots + w_n}$$

x_i - soil date of i horizon

w_i - thickness of i horizon

OR – organic matter %, in the depths 0-10, 10-30, 30-50, 50-70, 70-100, 0-50 cm depths

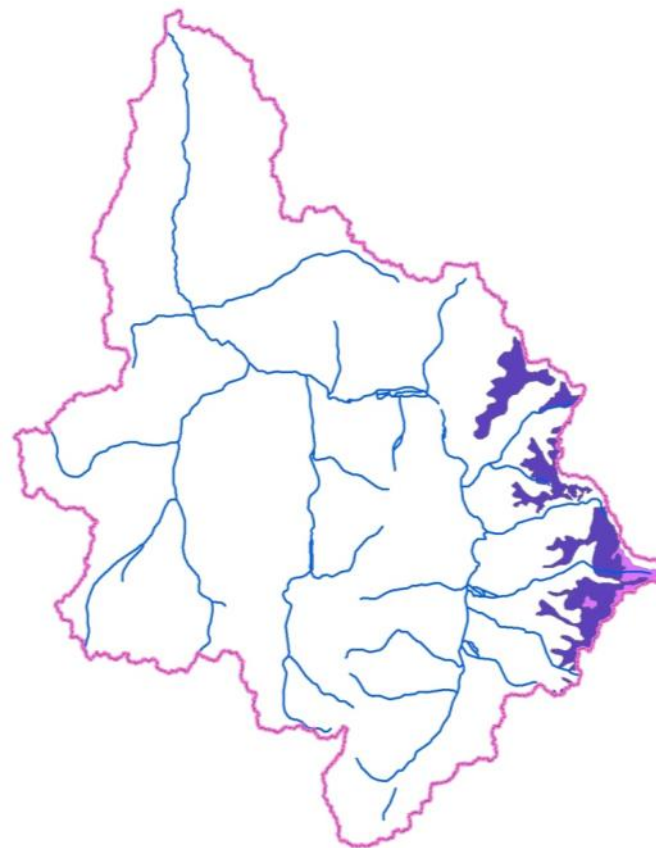
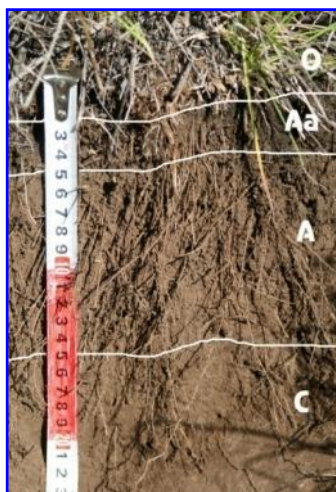
Attributes of SOIL_KHARAA_2008										
FID	Shape	CODE	FIELDNAME1	OR_10	OR_30	OR_50	OR_70	OR_100	OR_A50	SAND_10_11
0	Polygon	15	Kastanozems	0.8	0.192	0.12	0.12	0.12	0.2848	46.04768
1	Polygon	13	Kastanozem Sceletic	3.366	1.74	0.75	0.5725	0.04	1.6692	50.43728
2	Polygon	15	Kastanozems	0.8	0.192	0.12	0.12	0.12	0.2848	46.04768
3	Polygon	11	Kastanozems	1.21	0.8	0.2525	0.12	0	0.663	54.9732
4	Polygon	2	Leptic Chernozems	5.275	4.21	0	0	0	2.739	37.049
5	Polygon	15	Kastanozems	0.8	0.192	0.12	0.12	0.12	0.2848	46.04768
6	Polygon	2	Leptic Chernozems	5.275	4.21	0	0	0	2.739	37.049
7	Polygon	13	Kastanozem Sceletic	3.366	1.74	0.75	0.5725	0.04	1.6692	50.43728
8	Polygon	11	Kastanozems	1.21	0.8	0.2525	0.12	0	0.663	54.9732
9	Polygon	13	Kastanozem Sceletic	3.366	1.74	0.75	0.5725	0.04	1.6692	50.43728

Soils of Kharaa river basin

Nature region	FAO soil classification	Mongolian soil classification	Profile No.
High mountain	Leptosols	Mountain meadow steppe	2
	Leptic Umbrisols	Mountain meadow	3
Mountain forest	Mollic Umbrisols	Mountain forest dark colored	1
	Gelic Umbrisols	Mountain taiga crymorphic soil	4
	Umbrisols	Mountain derno taiga	5
	Phaeozems	Meadow forest soil	10
	Phaeozems	Mountain dark colored peaty	14
Steppe South	Kastanozems	Meal carbonated dark kastanozem	21
	Kastanozems	Dark kastanozem	25
	Kastanozems	Dark kastanozem	26
	Kastanozems	Sairgarhag dark kastanozem	23
Steppe Middle	Kastanozems	Dark kastanozem	7
	Chernozems	Chernozem	9
	Kastanozem Sceletic	Sairgarhag kastanozem	13
Steppe North	Kastanozems	Sandy dark kastanozem	11
	Kastanozems	Sandy kastanozem	15
	Kastanozem Arenic	Sandy kastanozem	16
	Mollic Arenosols	Sand	17
Agriculture	Kastanozems Anthric	Sandy kastanozem	18
	Kastanozems Anthric	Meal carbonated dark kastanozem	19
	Kastanozems Anthric	Sandy non carbonated kastanozem	20
	Kastanozems Anthric	Sairgarhag dark kastanozem	22
Floodplain	Fluvisols	Alluvial meadow derno	6
	Salic Fluvisols	Alluvial meadow salty	8
	Fluvisols	Alluvial meadow stepped	12
Salty depression	Solonchak	Solonchak	24

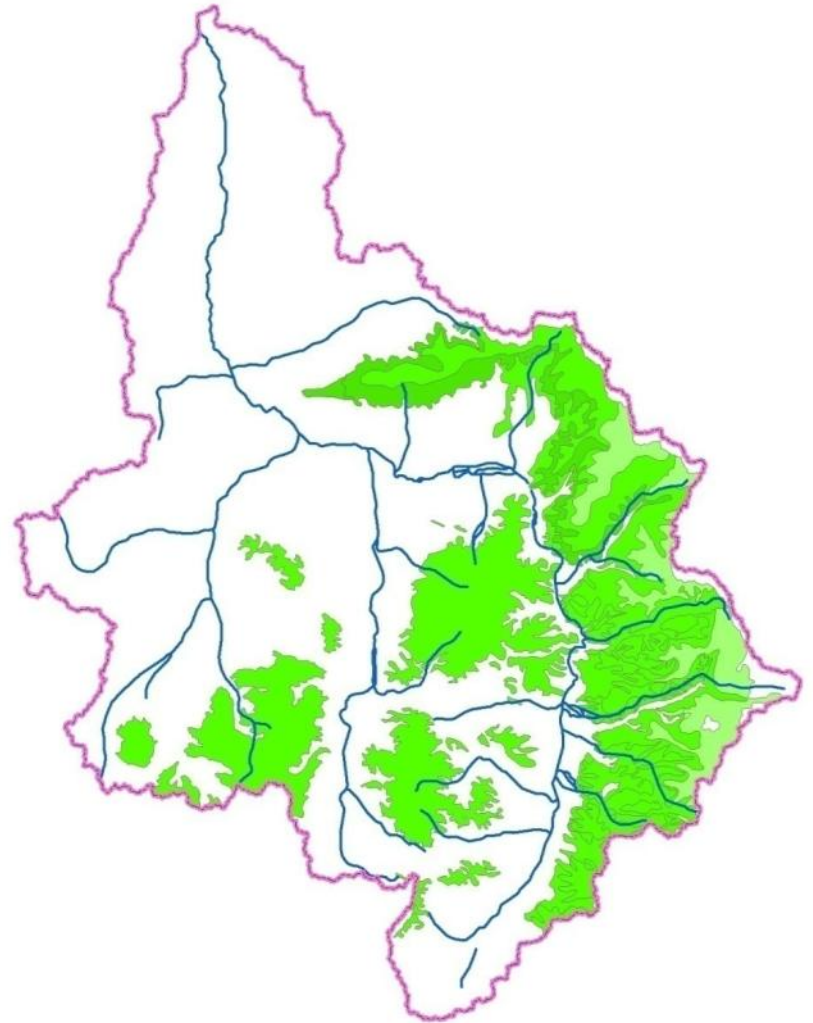
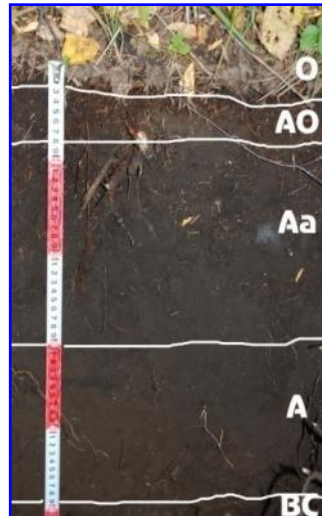
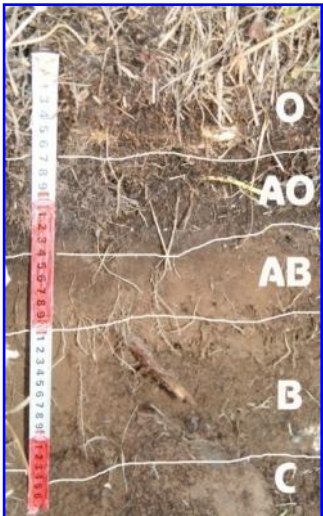
High Mountain soil

FAO soil classification	Mongolian soil classification
Leptosols	Mountain meadow steppe
Leptic Umbrisols	Mountain meadow



Mountain forest soil

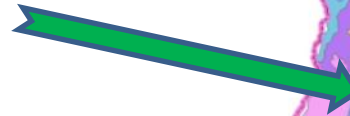
Mollic Umbrisols	Mountain forest dark
Gelic Umbrisols	Mountain taiga cryomorphic
Umbrisols	Mountain derno taiga
Phaeozems	Meadow forest soil



Steppe soil

North steppe soil

Loamy, Sandy, less stony,
more agriculture suitable



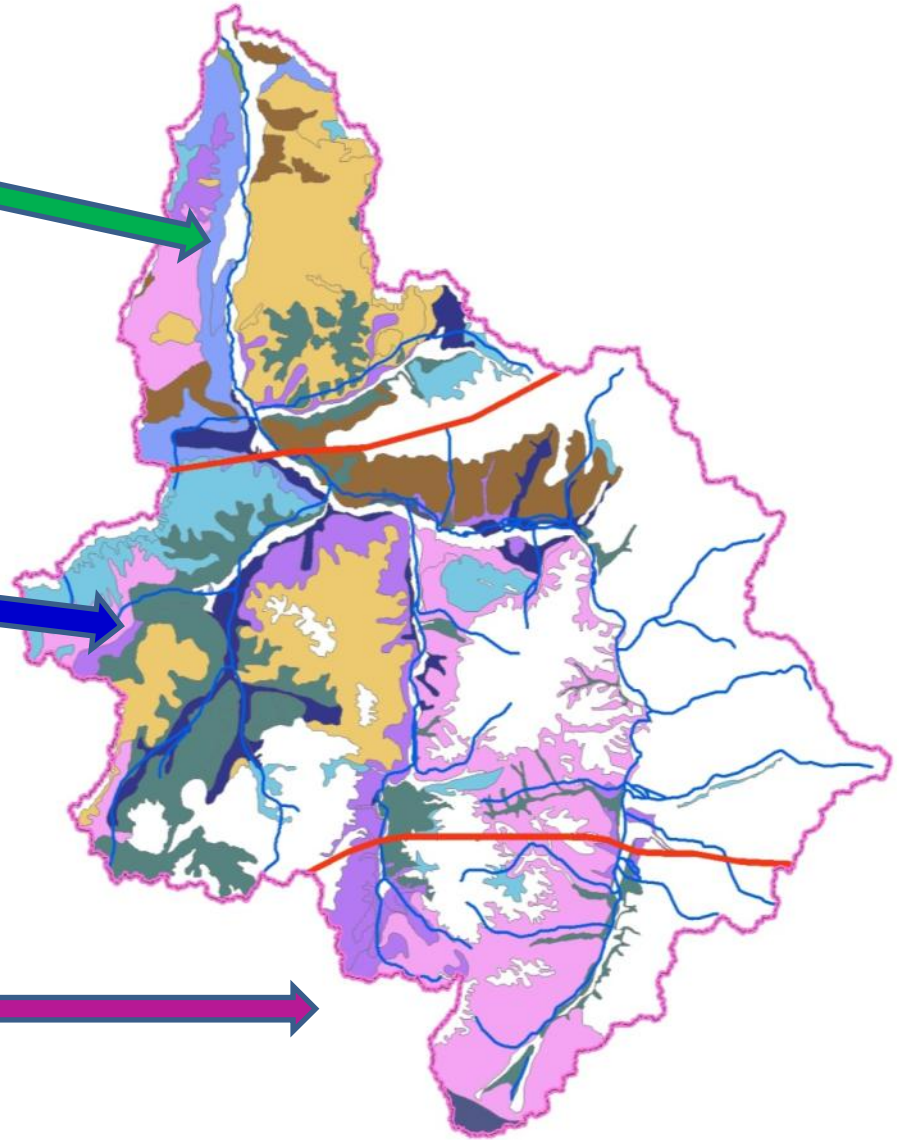
Middle steppe soil

Loamy, Silt, stony,
more agriculture suitable in west



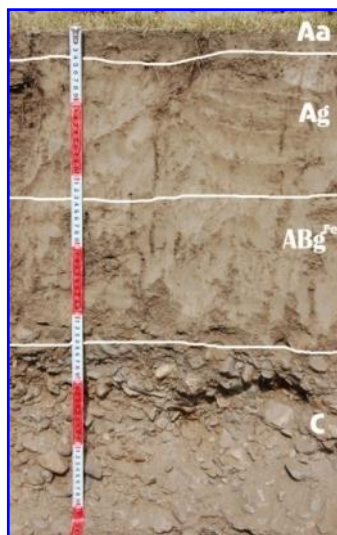
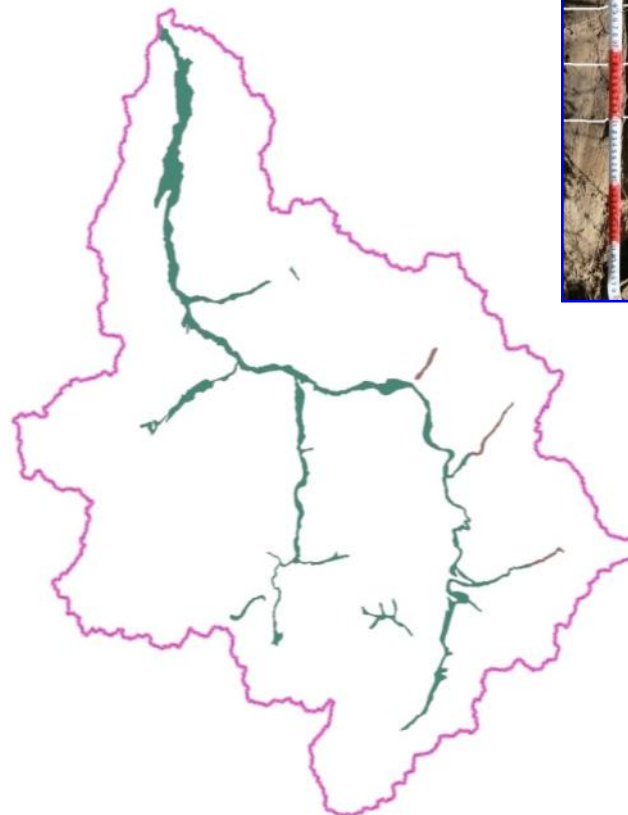
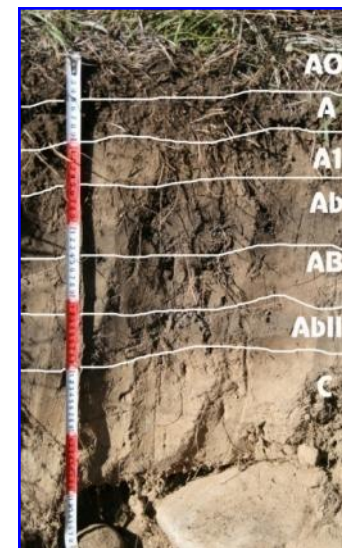
South steppe soil

Silt loam, more stony,
less agriculture suitable

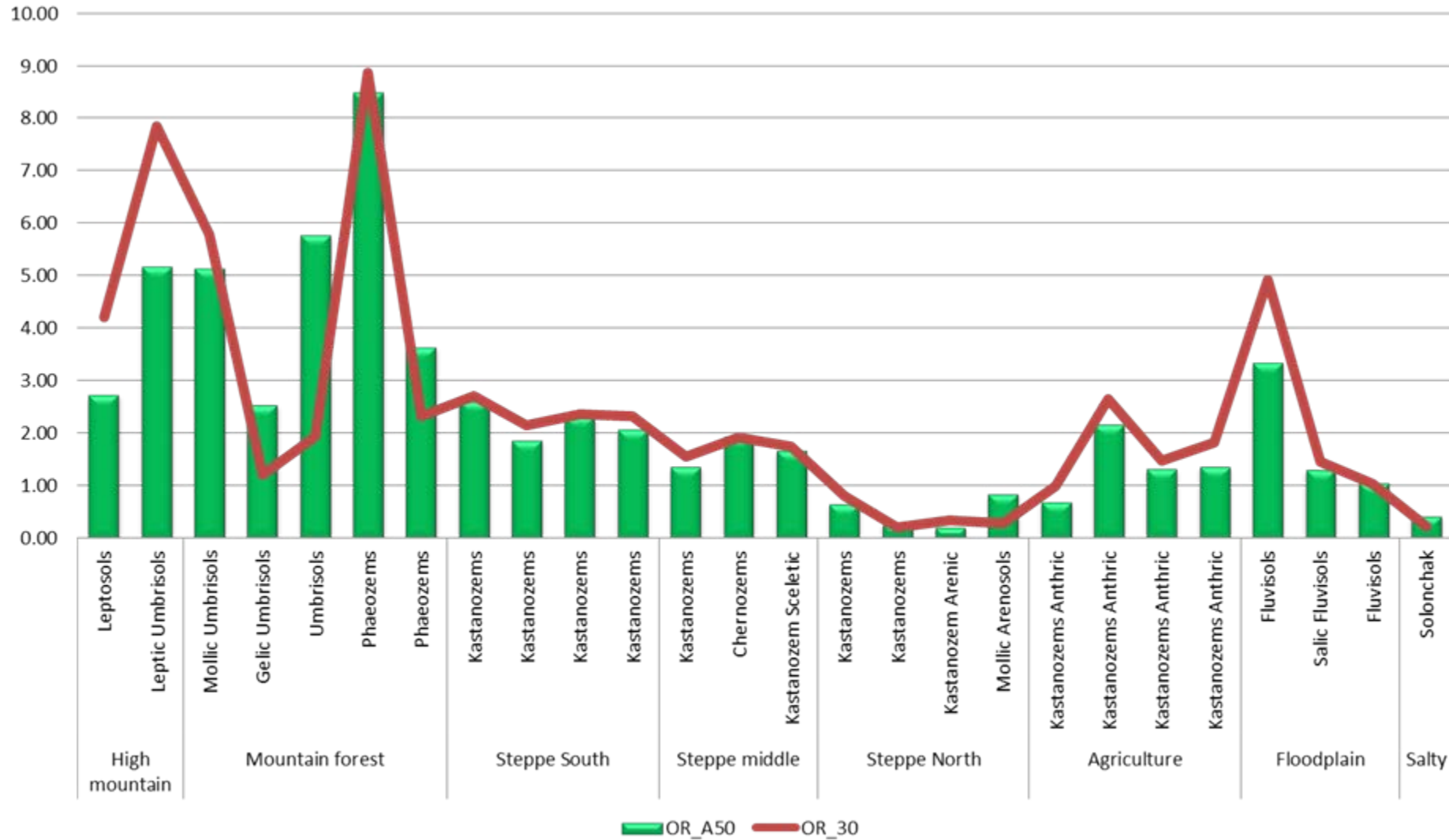


Floodplain soil

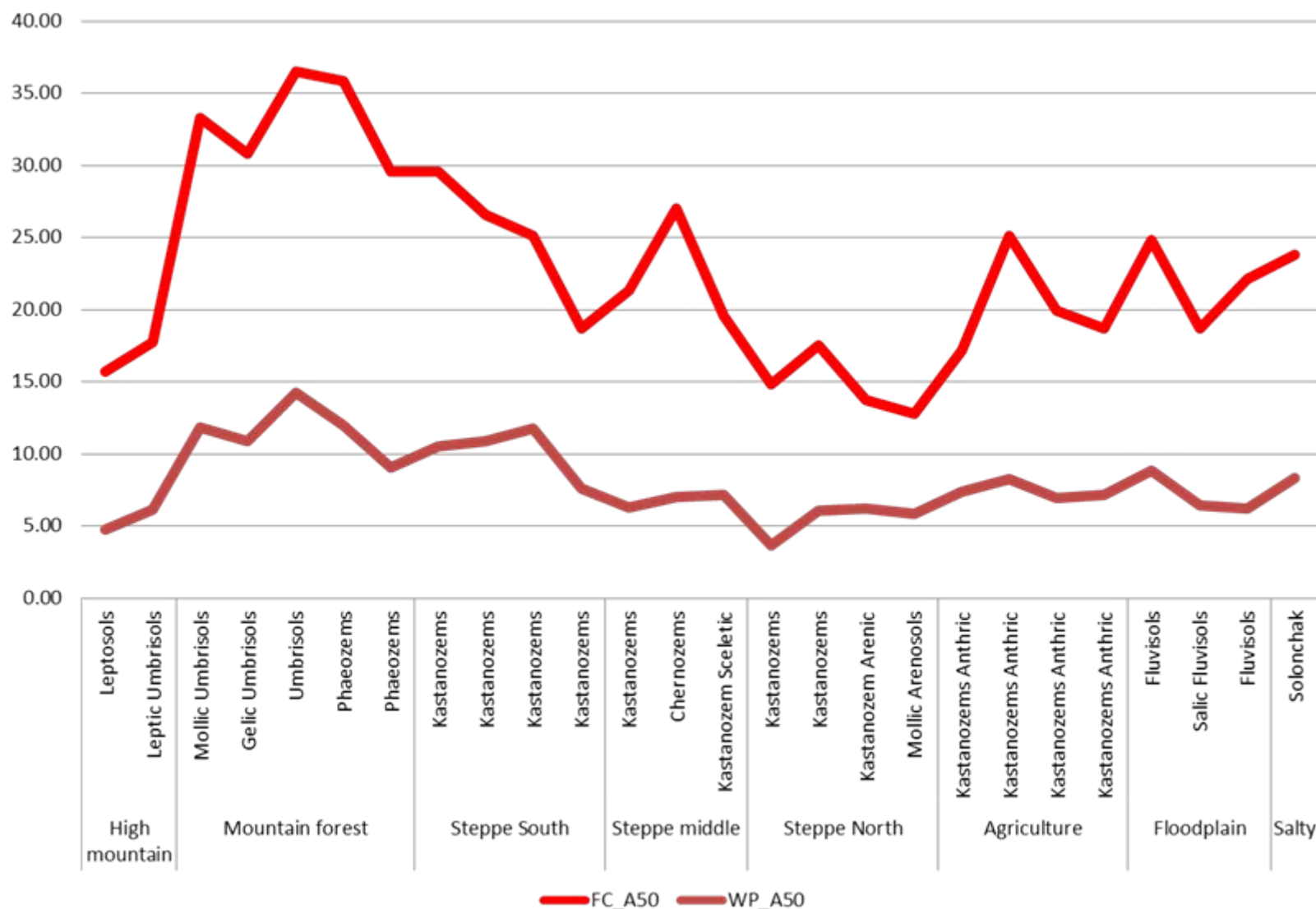
FAO soil classification	Mongolian soil classification
Fluvisols	Alluvial meadow derno
Salic Fluvisols	Alluvial meadow salty
Fluvisols	Alluvial meadow stepped



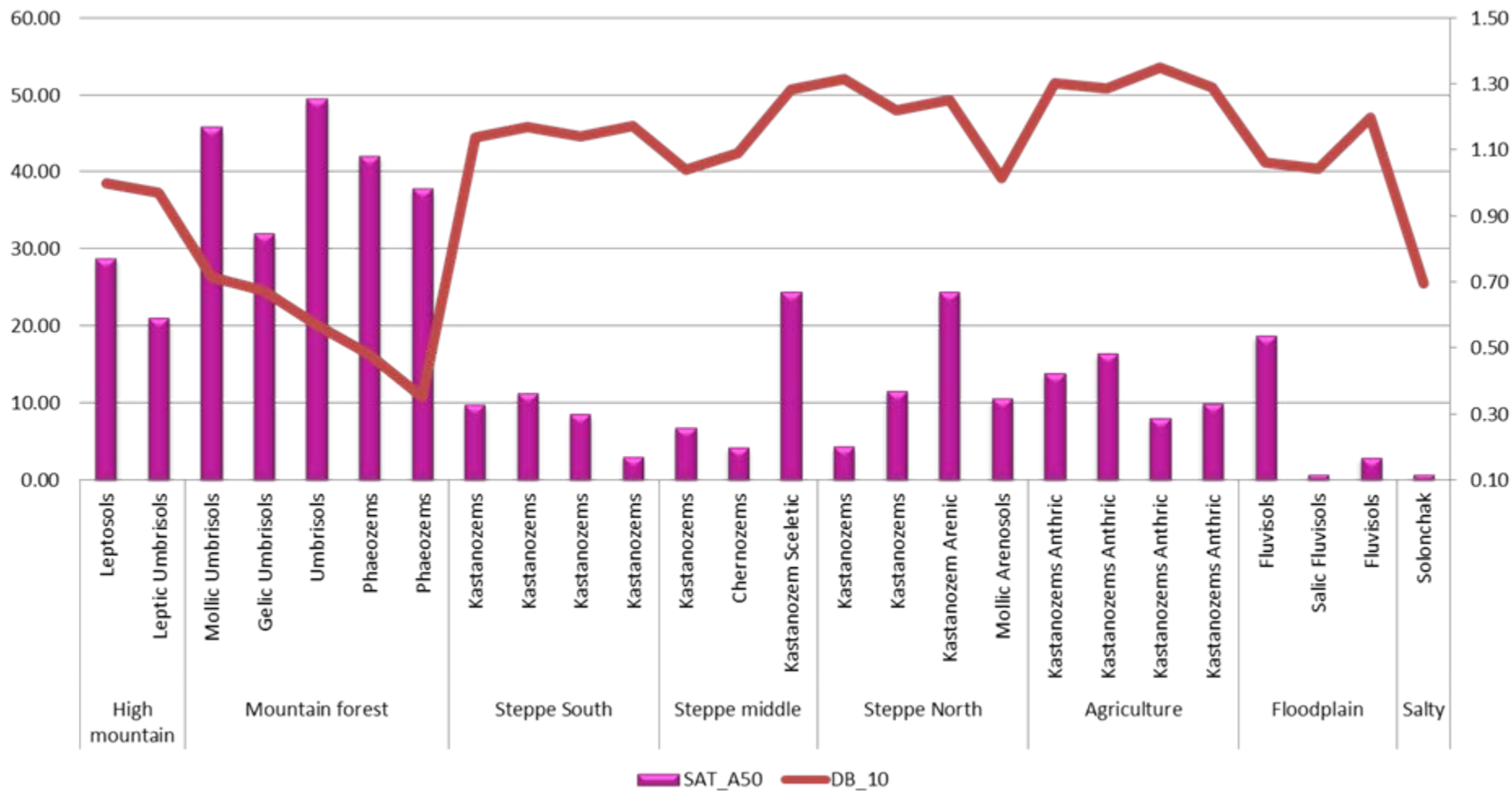
Soil organic content in 0-50 and 0-30 cm layers, %



Soil water holding capacity and wilting point, % (0-50 cm)

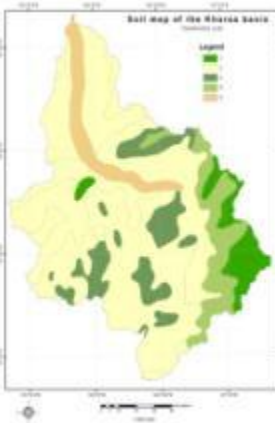
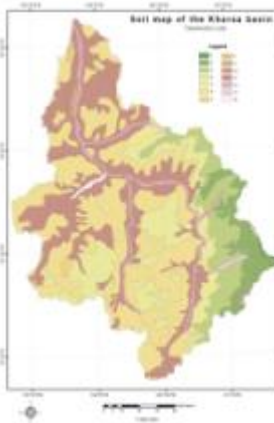
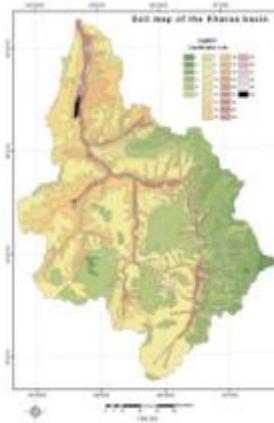


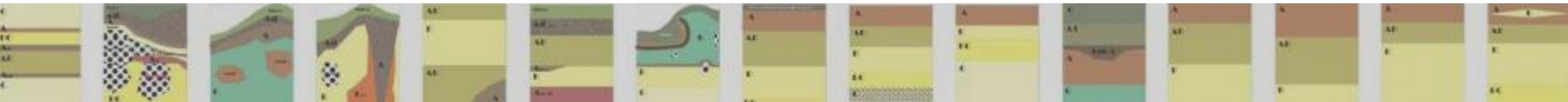
Soil infiltration rate and bulk density



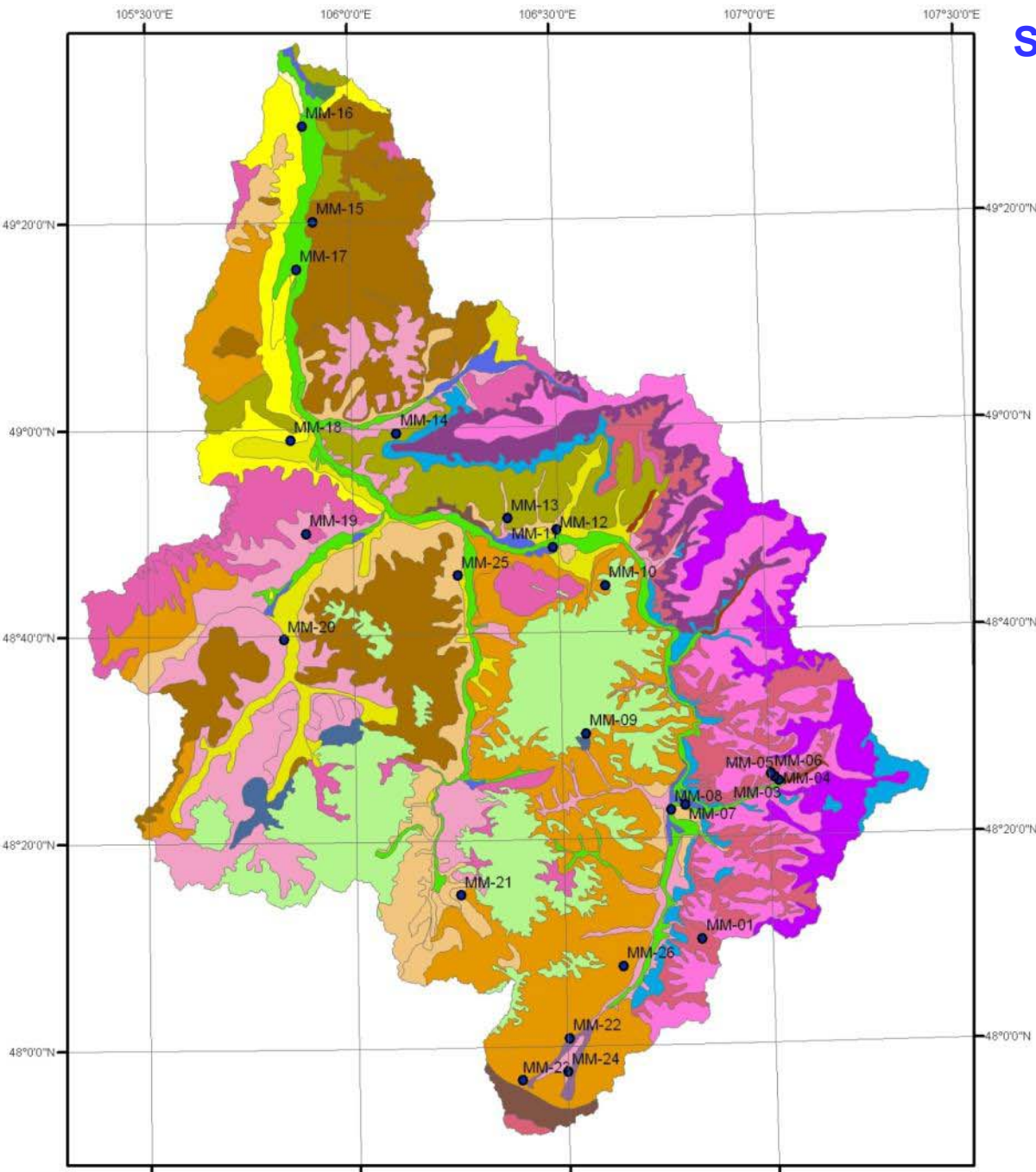
Soil map in the Kharaa basin

Outline
Background
Scientific methods, approaches
Data
Data preprocessing
Results
Problems for Soil study
Outlook (Future works)

				
Масштаб (Scale)	1:5 000 000	1: 2 500 000	1: 1 000 000	1: 250 000
Хэний ангилал (Which class)	FAO classification (LEVEL1, 2003 years)	Mongolian Classification (Book that Soil of Mongolia)	Mongolian Classification (National Soil Atlas of Mongolia)	Both of MOMO project and Institute of Geography
Ангилалын нэгж (Class counts)	5	5	14	29
Àòððéáóò ìÿäÿüíèé ò°ð°ë	OC, N, pH, Particle size, DB, DP	Soil class, Particle size	Soil class, Soil usage	OC, N, pH, Exchangeable cations, CO2, Particle size, DB, DP, Porosity, Class



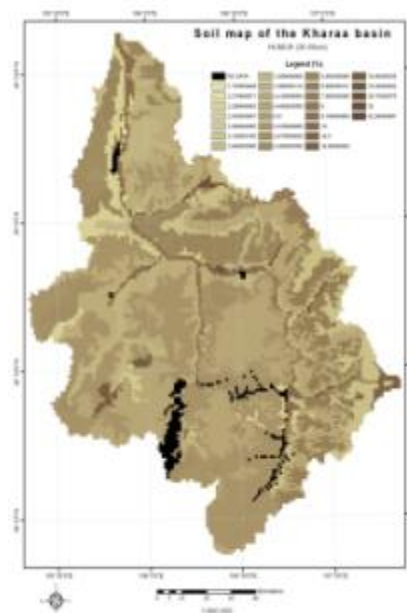
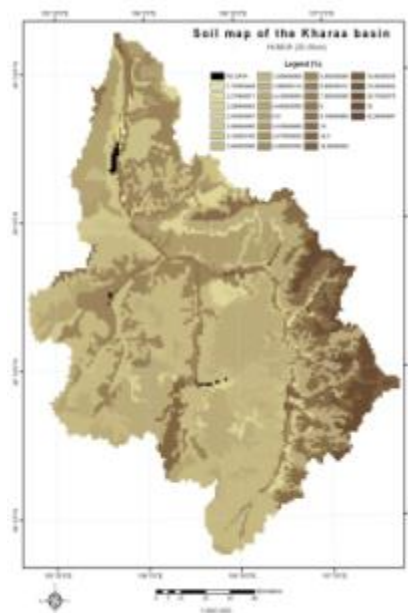
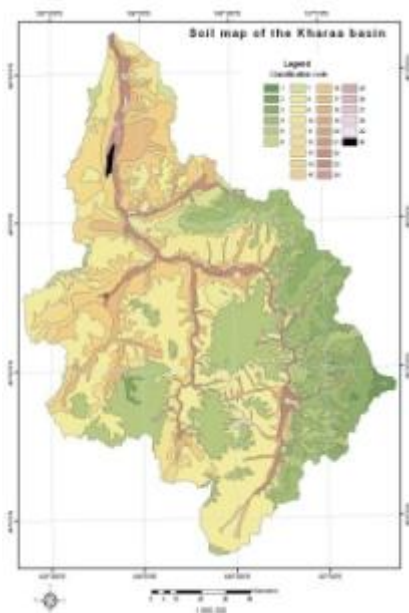
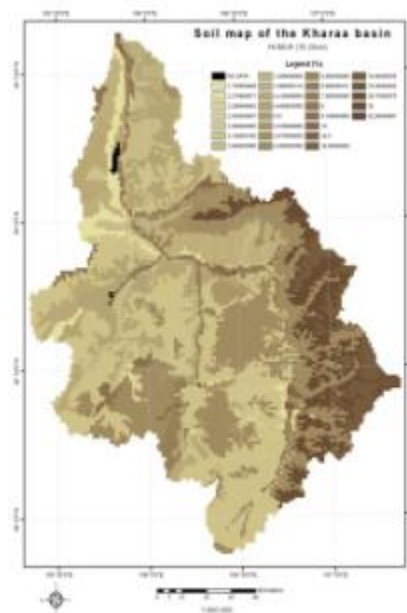
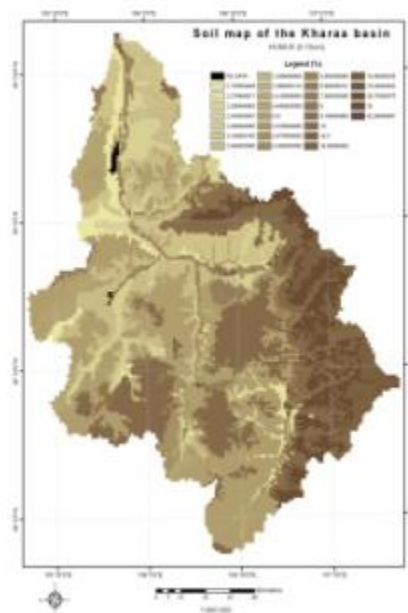
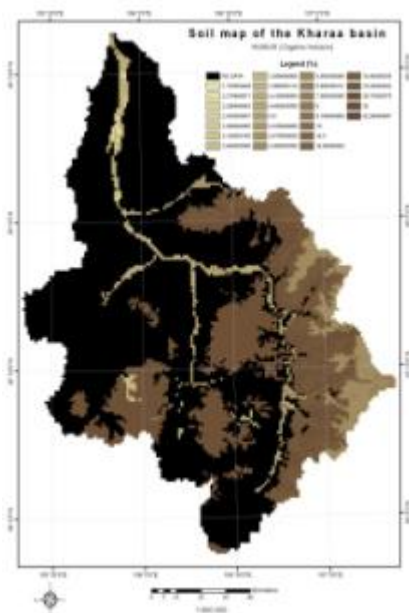
Soil map of Kharaa river basin



Legend

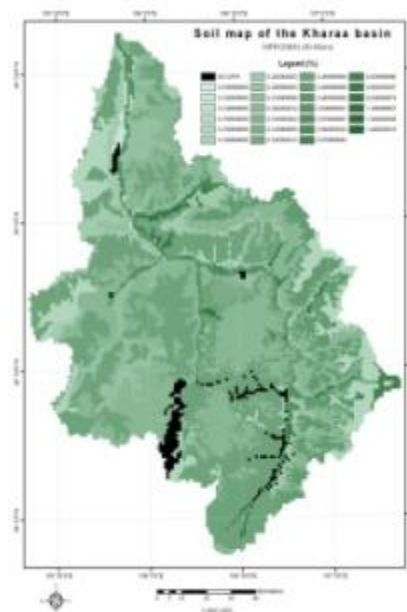
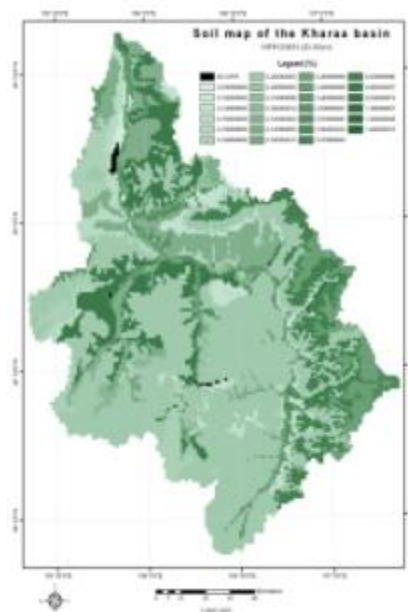
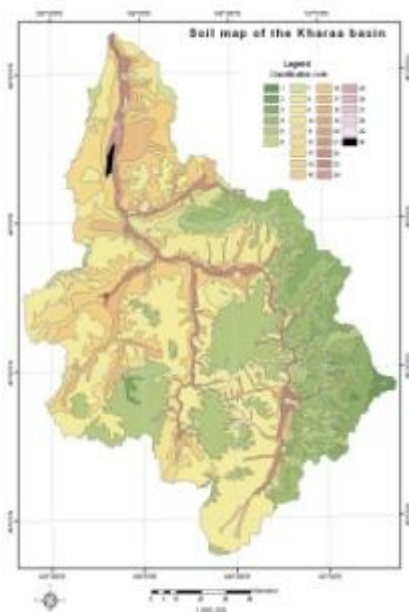
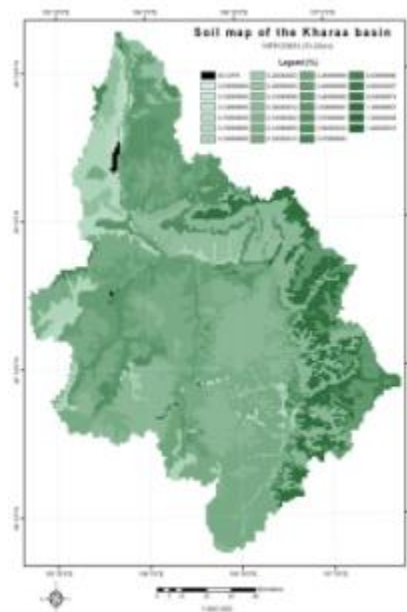
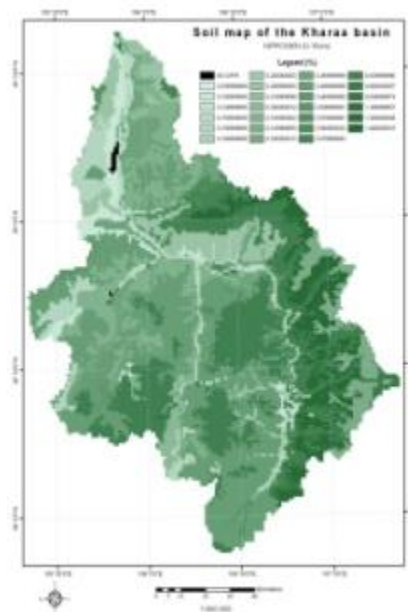
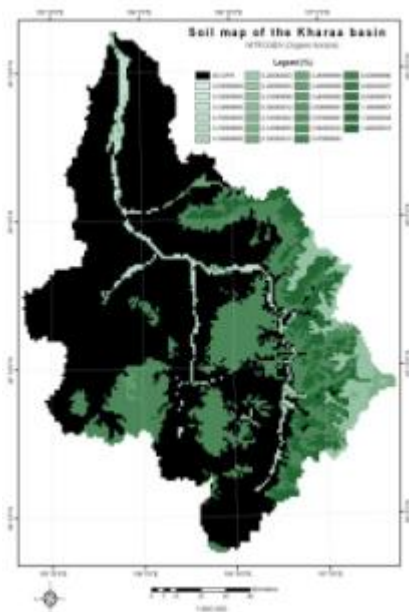
- Umbrisols (Siltic)
- Umbrisols
- Solonchaks
- Salic Fluvisols
- Phaeozems
- Mollic Umbrisols
- Mollic Solonchaks
- Leptic Chernozems
- Kastanozems (Siltic)
- Kastanozems (Sceleitic)
- Kastanozems (Arenic, Anthric)
- Kastanozems (Arenic)
- Kastanozems (Anthric)
- Kastanozems
- Kastanozem (Sceleitic)
- Histosols
- Gelic Umbrisols
- Fluvisols
- Cryosols
- Chernozems
- Cambisols
- Calcic Kastanozems
- Arenosols
- kharaa_2008_profile

SOIL MAP OF THE KHARAA BASIN



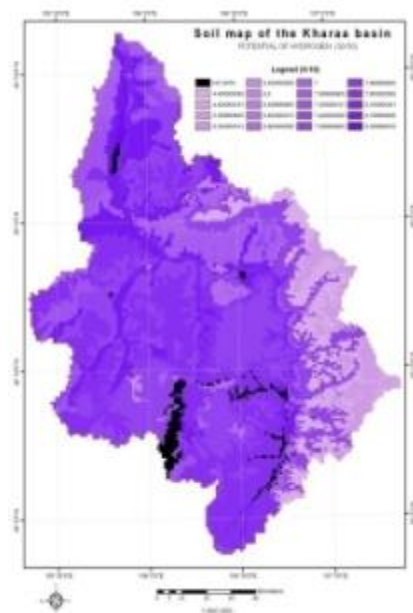
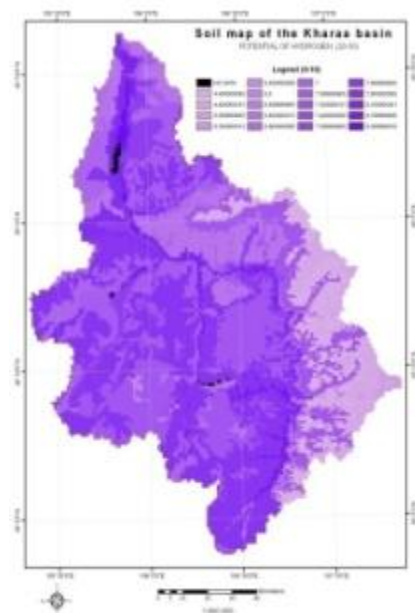
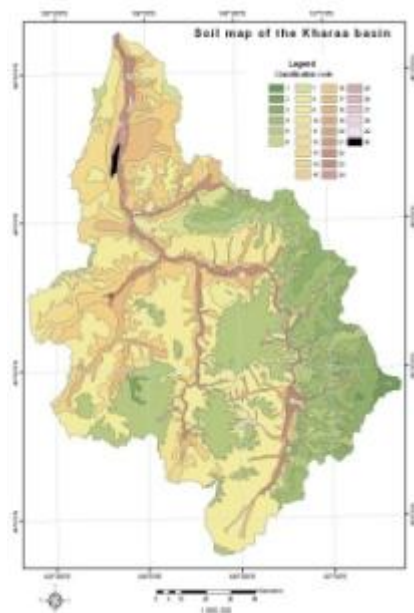
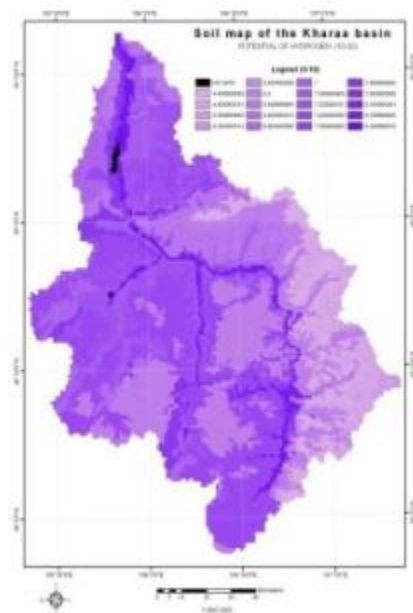
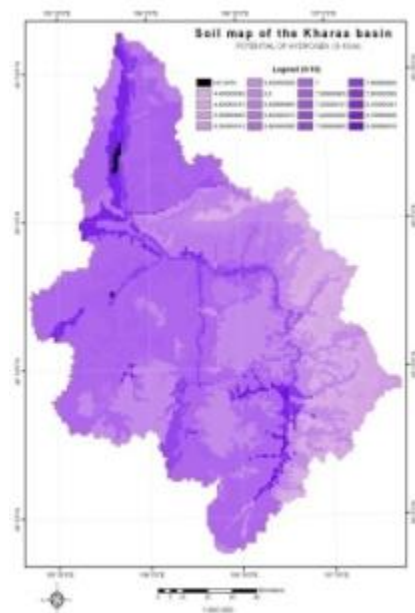
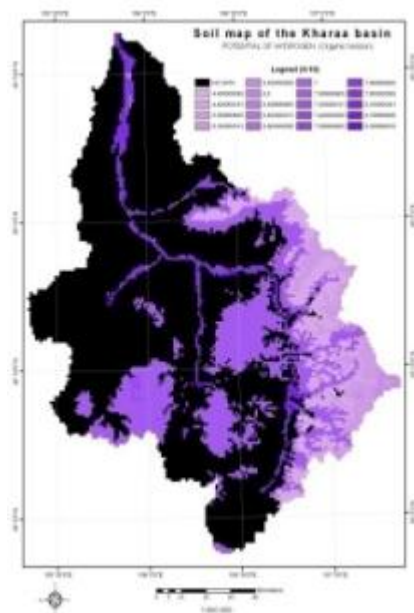
HUMUS
Units (%)

SOIL MAP OF THE KHARAA BASIN



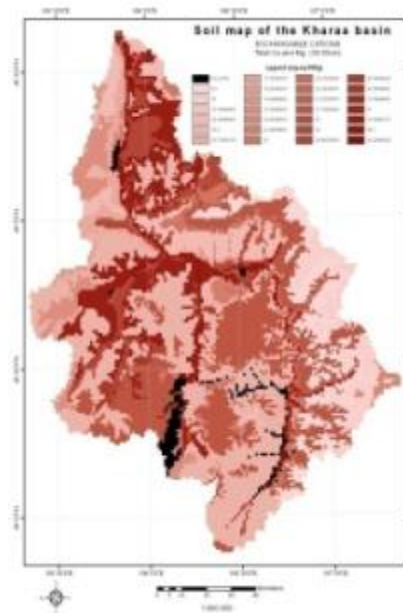
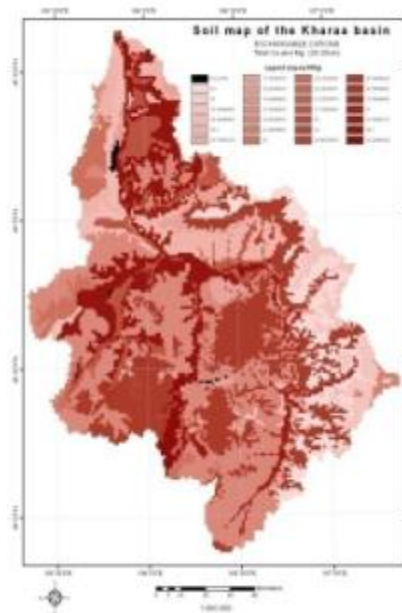
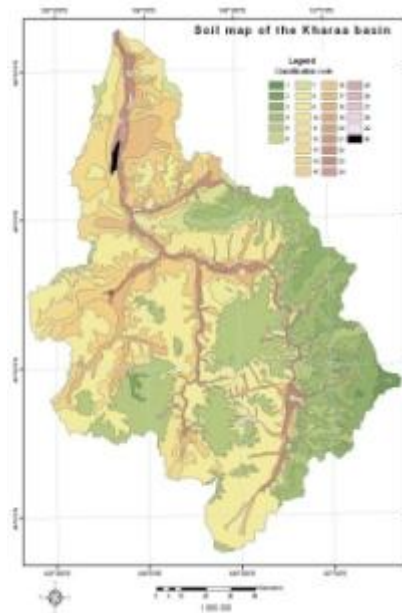
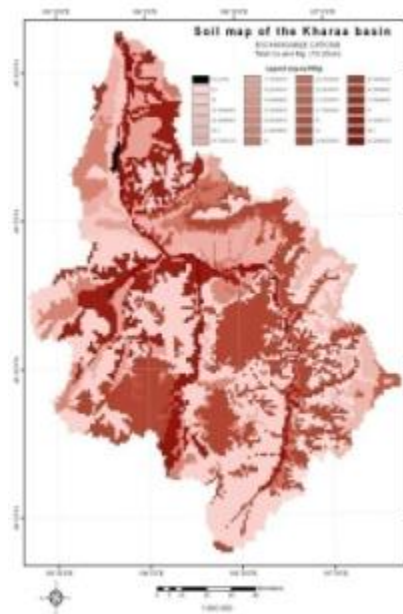
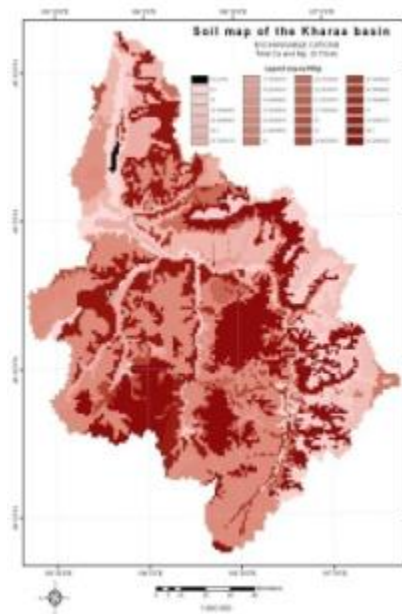
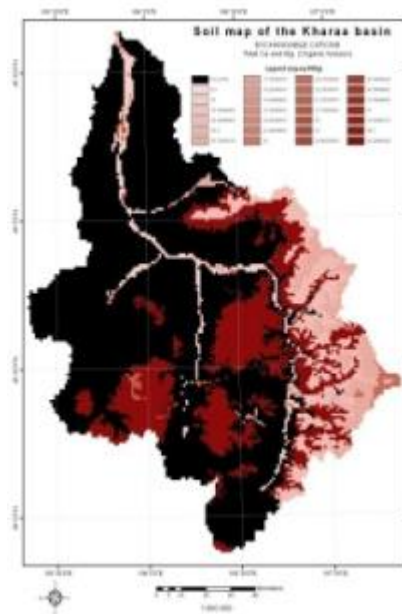
NITROGE
N
Units (%)

SOIL MAP OF THE KHARAA BASIN



pH
Units (1-10)

SOIL MAP OF THE KHARAA BASIN

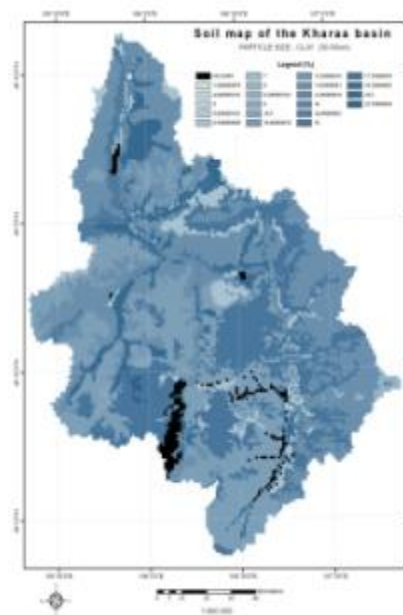
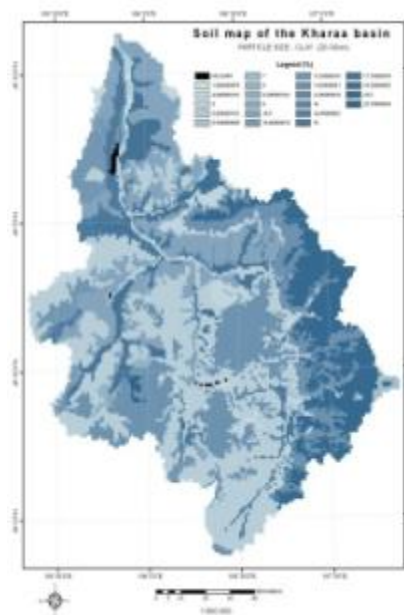
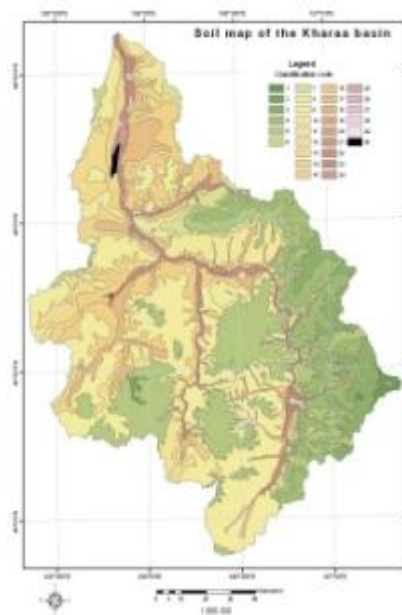
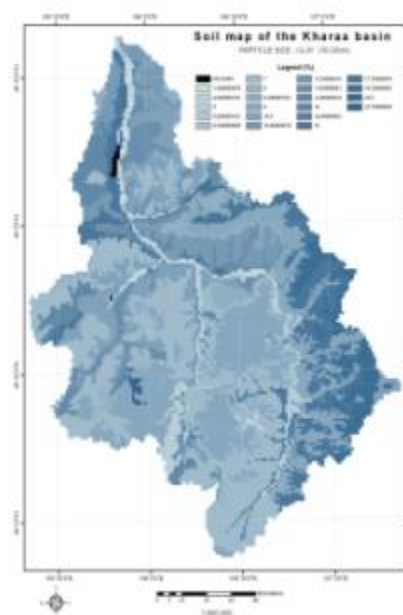
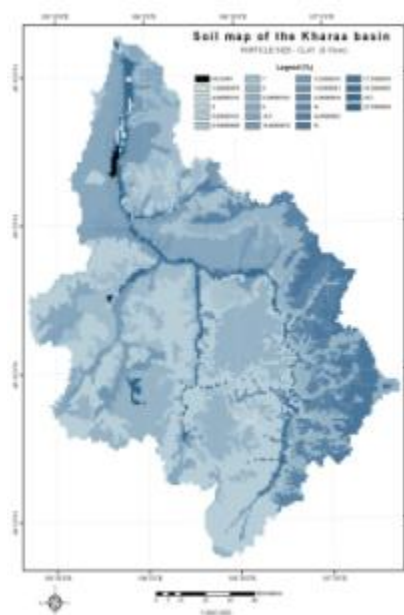
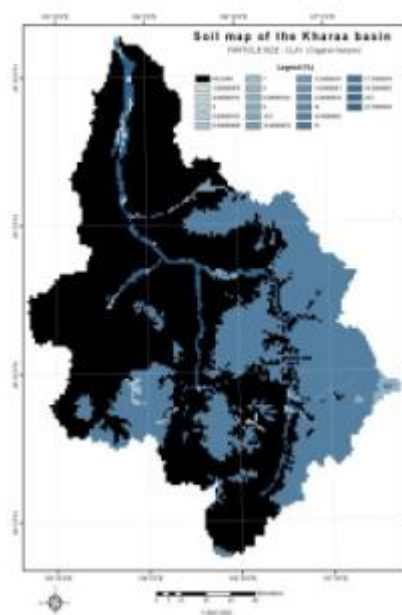


EXCHANGABLE CATIONS

SUM
(ca,mg)

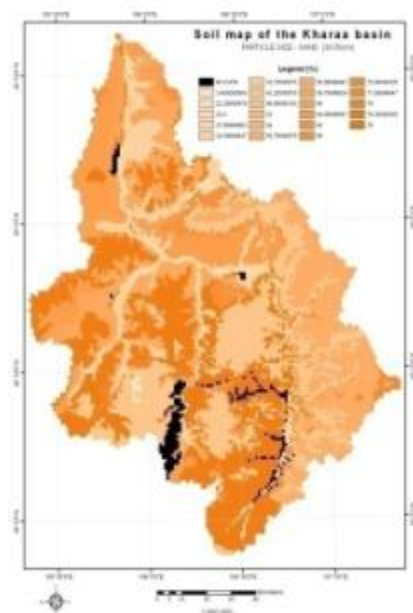
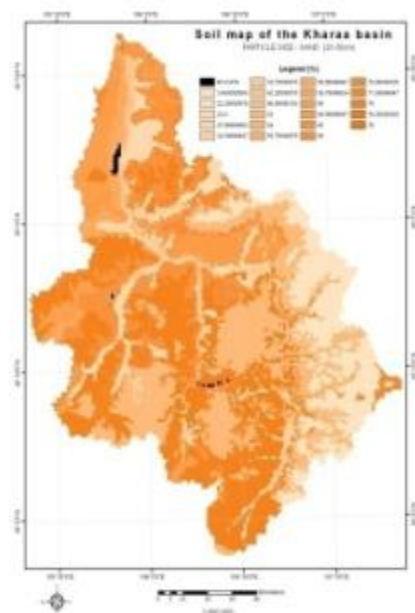
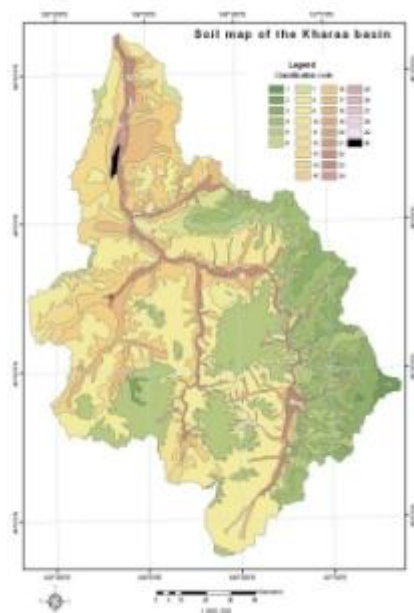
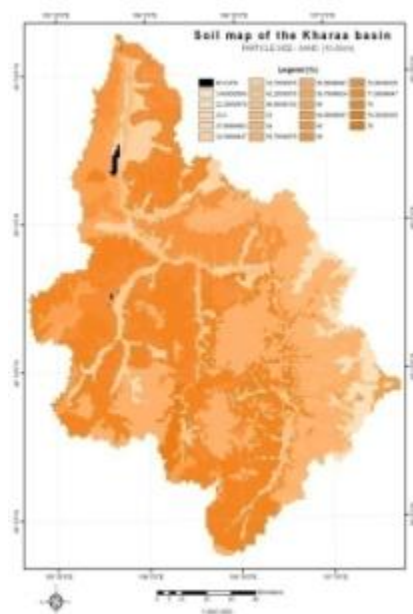
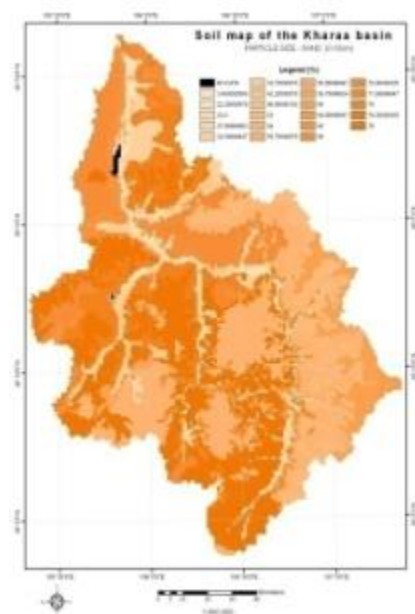
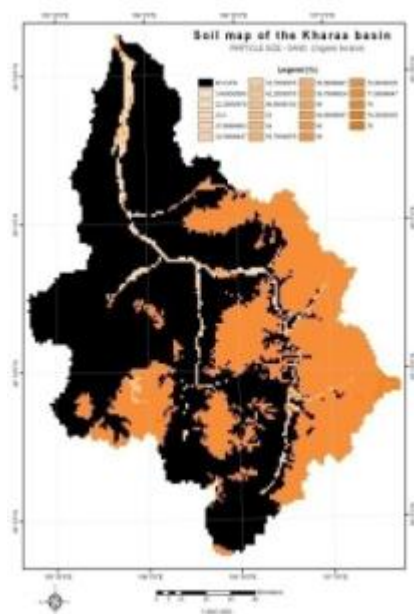
Units (mg-
eq/100g)

SOIL MAP OF THE KHARAA BASIN



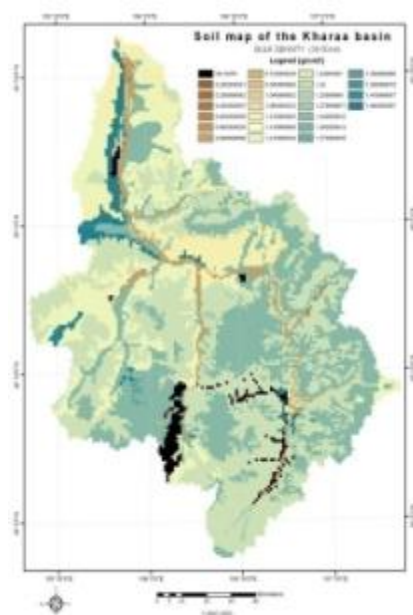
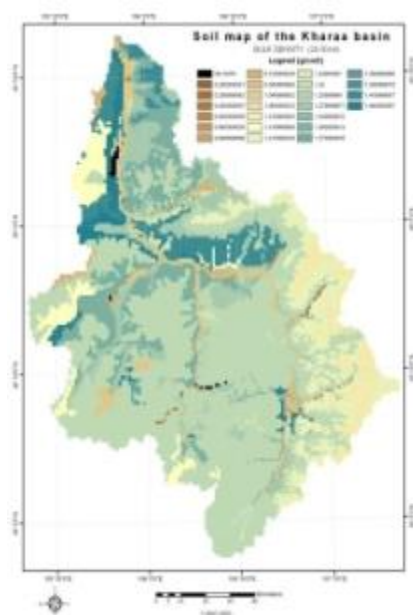
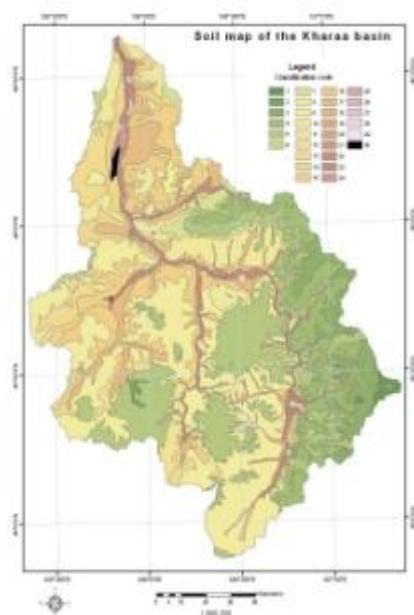
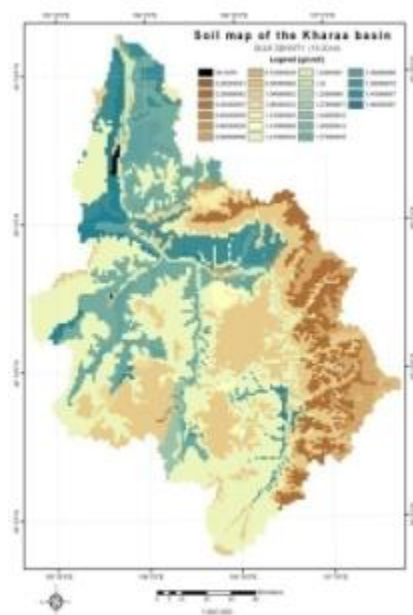
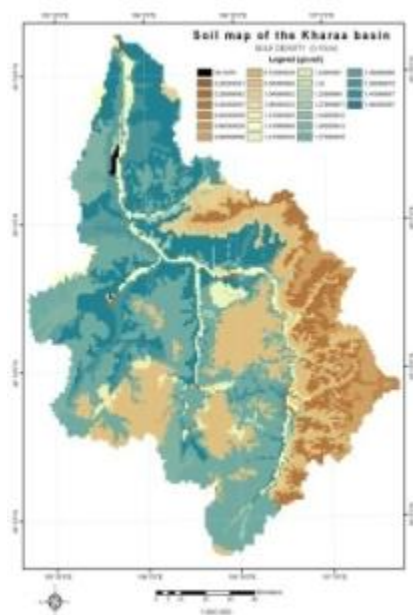
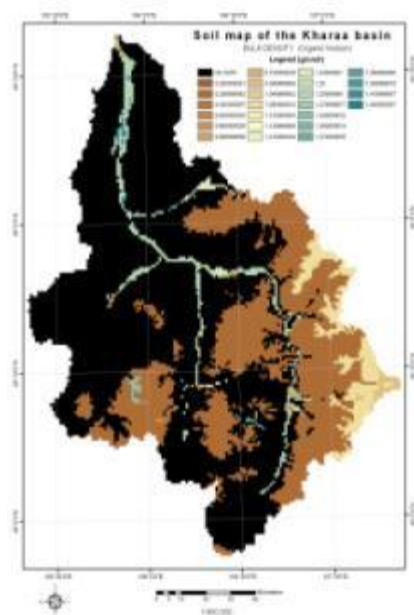
PARTICLE
SIZE
CLAY
Units (%)

SOIL MAP OF THE KHARAA BASIN



PARTICLE
SIZE
SAND
Units (%)

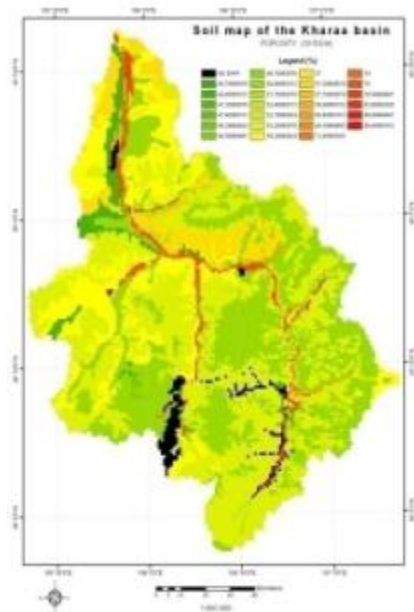
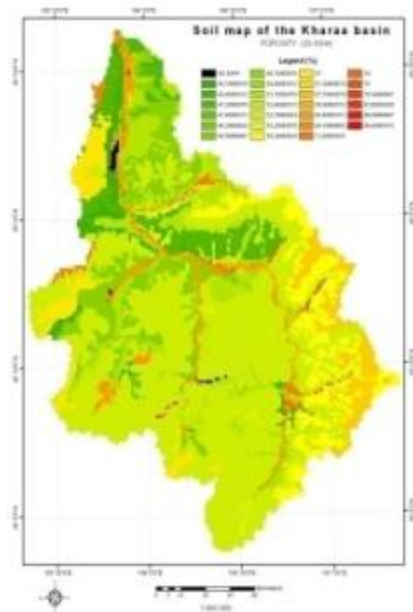
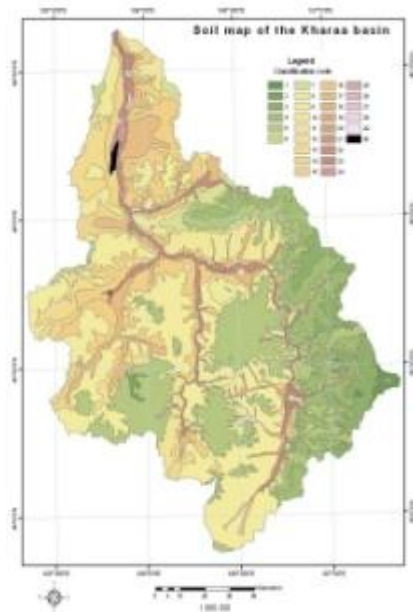
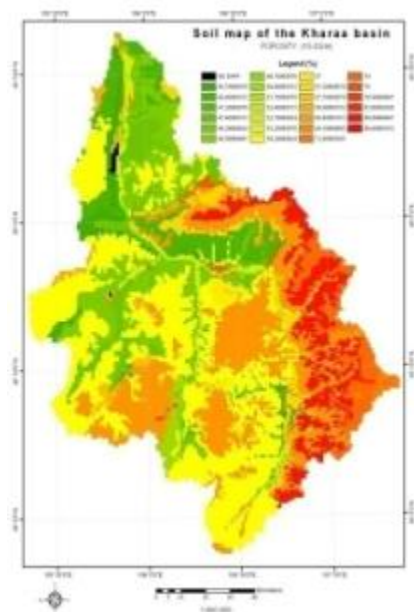
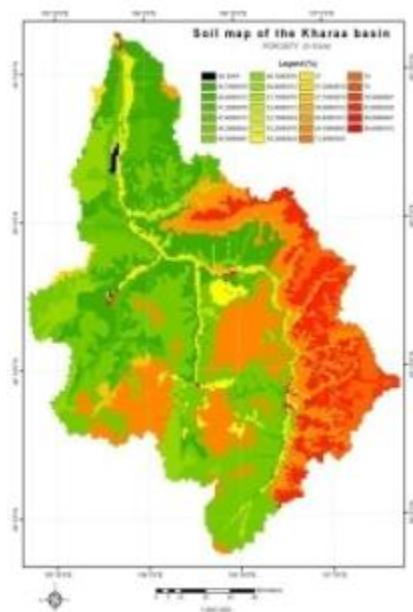
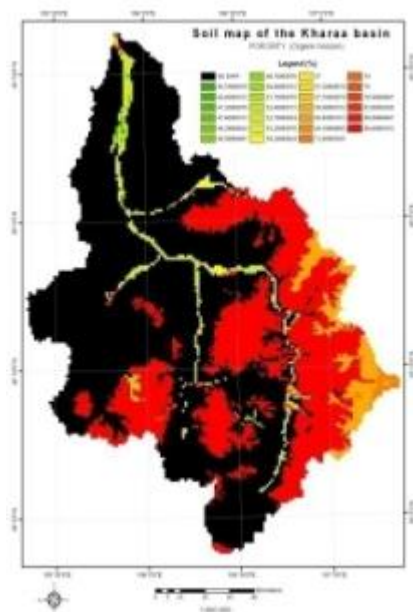
SOIL MAP OF THE KHARAA BASIN



BULK
DENSITY

Units
(g/cm³)

SOIL MAP OF THE KHARAA BASIN



POROSITY
Units (%)

SOIL MAPPING OF MONGOLIA

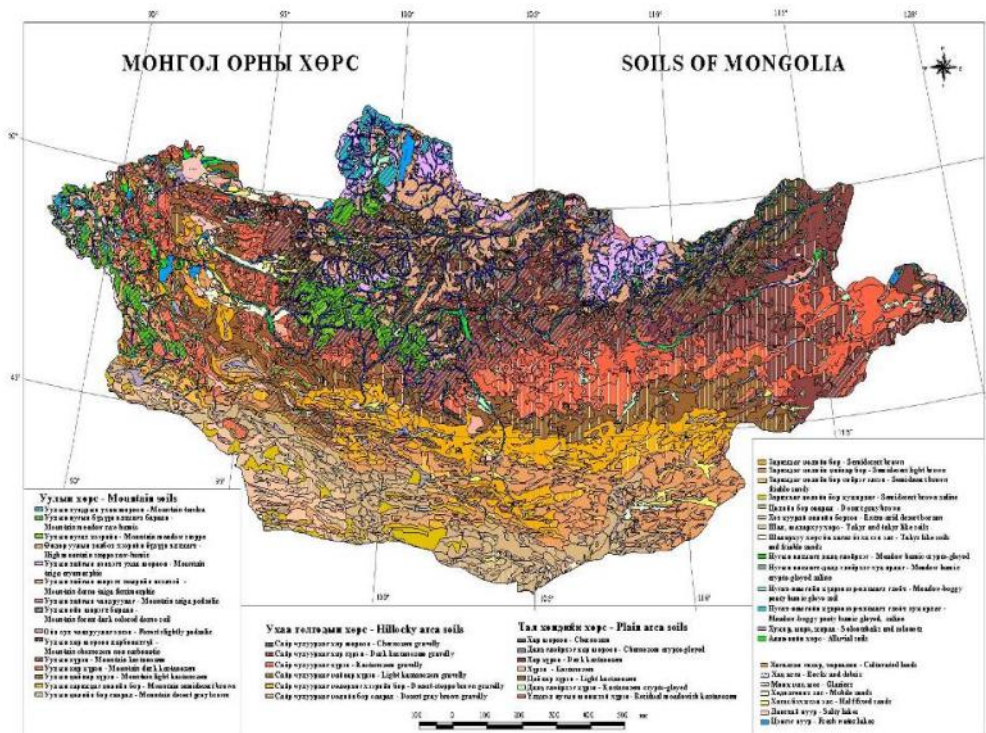
Converting existing soil maps to the digital format

Source data

Soil maps of Mongolia , scale 1 : 1 000 000, 1981

Soil maps of Mongolia , scale 1 : 2 500 000, 1979

Soil map of different regions, scale 1 : 100 000, 1 : 200 000



Software

ARC Map 9.3

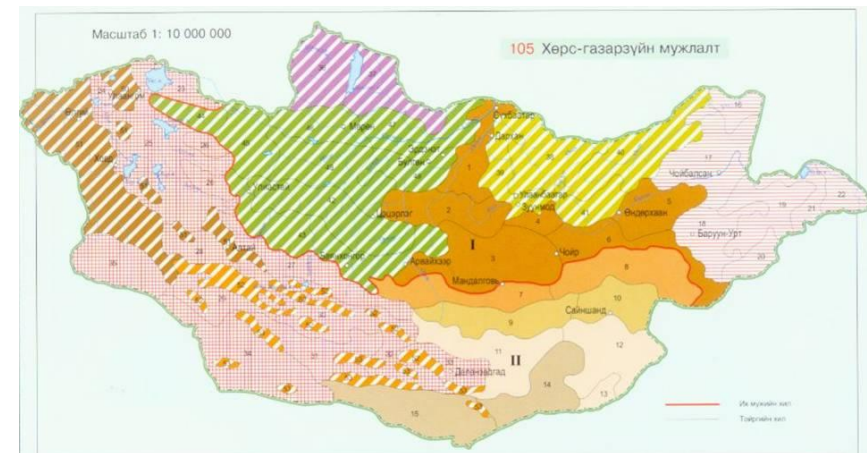
ERDAS Imagine 9.2

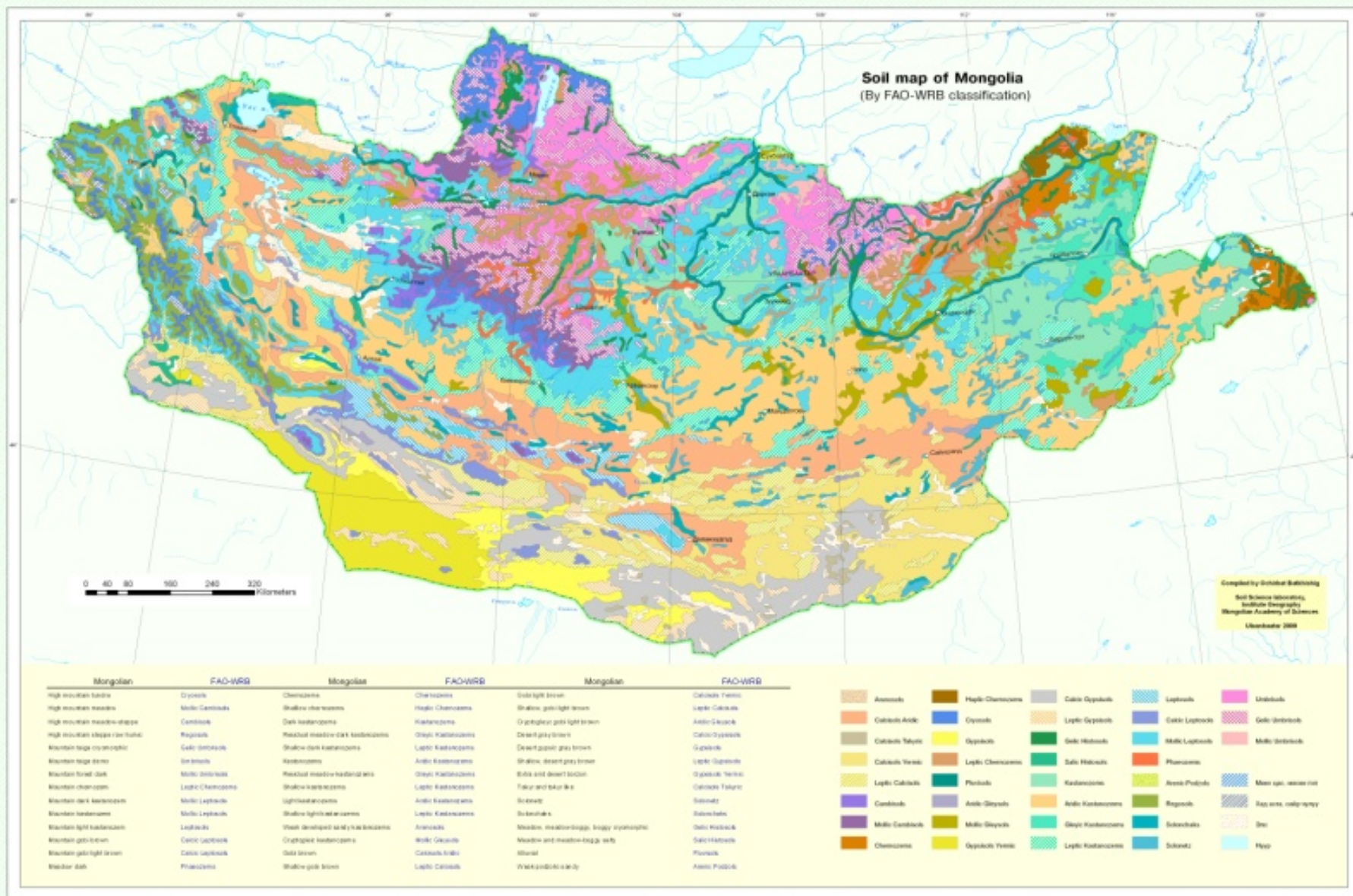
Soil classification of Mongolia

- Mongolia used geographical-genetical classification system, like Russian.
- **Now renewing classification system**

Mongolian soils divided by 2 parts

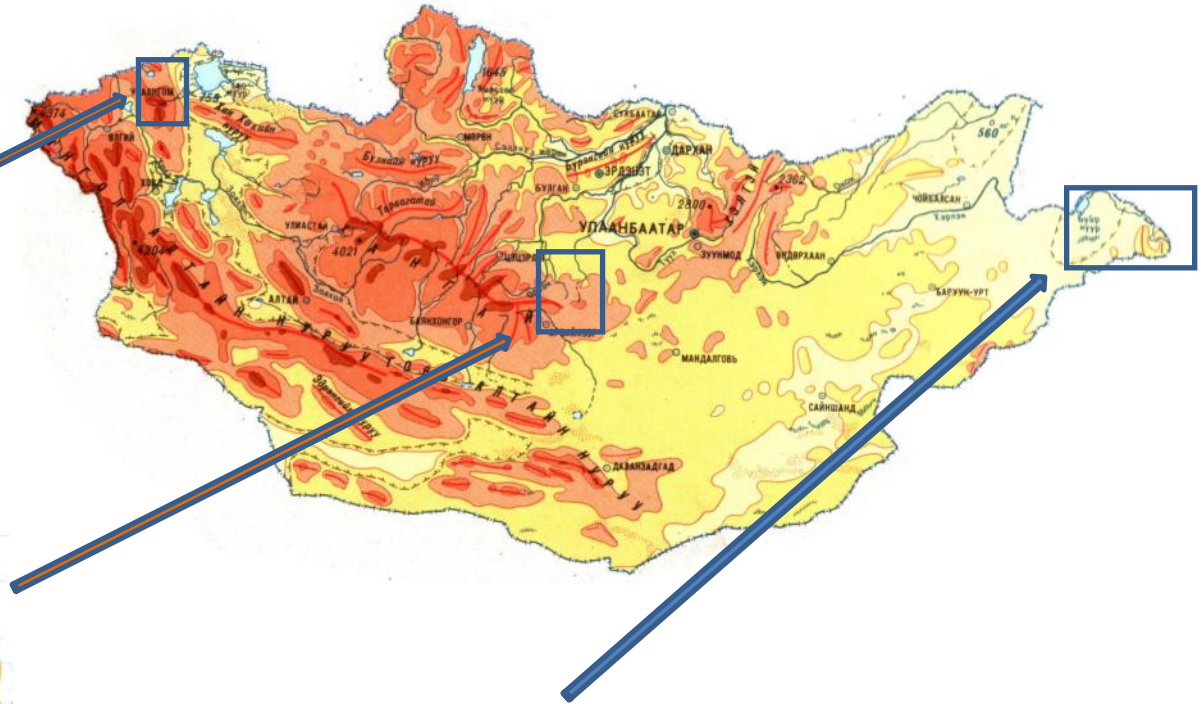
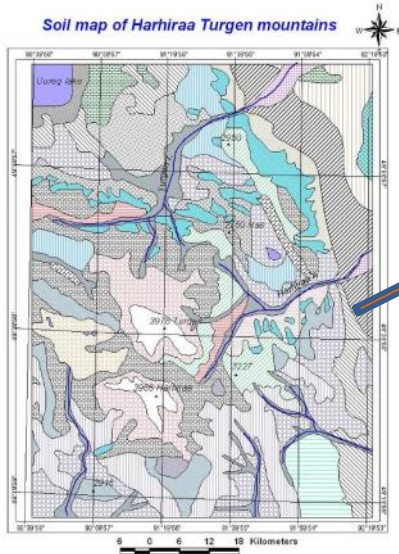
- Mountain soil
- Plain and intermountain valley soils
- Distinguished 36 types



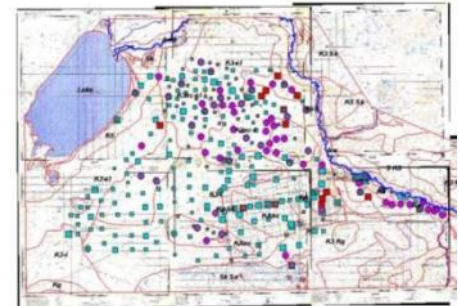
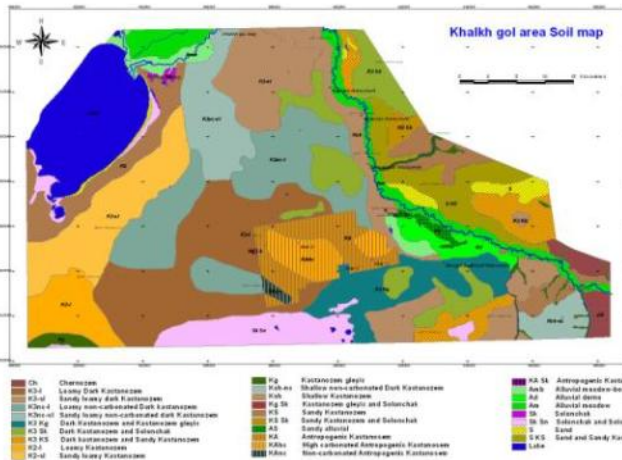
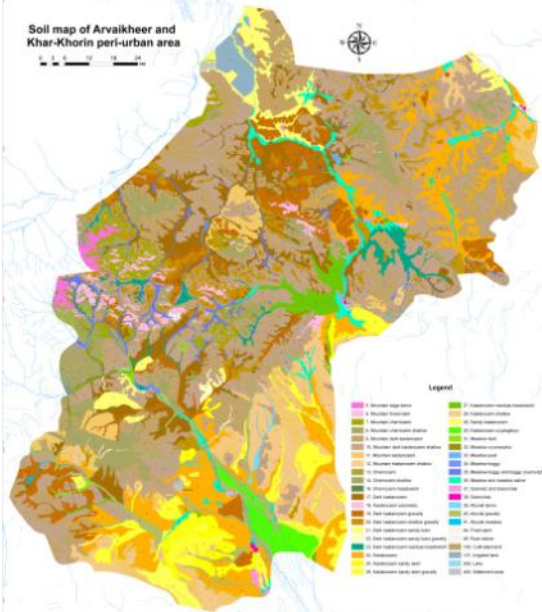


Compiling New soil maps in different regions of Mongolia

Soil map of Harhira Turgen mountains



Soil map of Arvaikheer and Khar-Khorin peri-urban area



Problems

- Soil database technology
- Digital soil mapping methodology not sufficient developed
- High resolution Satellite image availability (Spot, Ikonos, Quickbird etc.)

Thank you
for attention

