Similarity Analysis to Support the Dissemination of Sustainable Land Management Options in Central Asia

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Abbreviations and acronyms

AFESD	Arab Fund for Economic and Social Development
AWC	Available water content
CACILM	Central Asian Countries Initiative for Land Management
CFSR	Climate Forecast System Reanalysis
CGIAR	Consultative Group on International Agricultural Research
CGIAR CSI	CGIAR Consortium for Spatial Information
DEM	Digital Elevation Model
ESRI	Economic and Social Research Institute
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic information system
ICARDA	International Center for Agricultural Research in the Dry Areas
IWMI	International Water Management Institute
LP DAAC	Land Processes Distributed Active Archive Center
SRTM	Shuttle Radar Topography Mission
UNU	United Nation University
USGS	United States Geological Survey
USDA	United State Department of Agriculture

Table of Contents

Acknowledgments **1**
Abbreviations and acronyms **2**
List of Maps 4
List of Tables 5
List of Figures 5
List of Appendixes 6
Introduction **7**
Similarity Criteria **9**
Data sources and data preparations **10**
Data sources 10
Data preparations 11

Similarity analysis results – Part A **38**
Potential areas for out-scaling raised-bed technology within the Irrigated agro-ecosystem 38
Potential areas for out-scaling conservation agriculture within the rainfed agro-ecosystem 40
Potential areas for out-scaling agro-forestry technologies within the mountain agro-ecosystem 41
Potential areas for out-scaling pasture improvement technologies within the rangelands agro-ecosystem 42
Similarity analysis results – Part B **45**
Verification of the similarity maps based on national experts' participation and country level data 45

Similarity Maps of Central Asian Countries **53**

Appendixes **60**

Works Cited **66**

List of Maps

Map 1: Digital elevation model and slopes in Central Asia 12
Map 2: Slope degree required for irrigated agro-ecosystem 13
Map 3: Slope degree required for rainfed agroecosystem 13
Map 4: Slope degree required for mountain agro-ecosystem 14
Map 5: Slope degree required for the potential area for out-scaling pasture improvement (Slope degree >12) – Option 1 14
Map 6: Areas with altitude > 800 m 15
Map 7: Land degradation classes 16
Map 8: Degraded areas including areas with weak, medium to strong degradation as well as bareland areas 18
Map 9: Data used to identify the land use criteria for irrigated agro-ecosystem 20
Map 10: Area with large scale irrigation 20
Map 11: Data used to identify the land use criteria for rainfed agro-ecosystem 21
Map 12: Crop area in Central Asian countries 21
Map 13: Data used to identify the land use criteria for mountain agroecosystem 22
Map 14: Data used to identify the land use criteria for rangeland agro-ecosystem 23
Map 15: Rangeland area 23
Map 16: Livestock density map 24
Map 17: Areas with high and moderate livestock density 24
Map 18: Precipitation distribution 25
Map 19: Areas with average precipitation of 300-600 mm - Rainfed Agro-ecosystem 26
Map 20: Areas with average precipitation of > 500 mm - Mountain Agro-ecosystem 26
Map 21: Clay content 10%-75% physical clay 29
Map 22:Clay Content, %: (20-75) physical clay 29
Map 23: Soil depth classes in Central Asian countries 30
Map 24: Area with soil depth > 50 cm 31
Map 25: Top-soil electrical conductivity 32
Map 26: Sub-soil electrical conductivity 32
Map 27: Soil salinity < 8 dS m^{-1} 33
Map 28: The global lakes and wetlands database (GLWD) - Level 1 34
Map 29: The global lakes and wetlands database (GLWD) - Level 2 35
Map 30: The global lakes and wetlands database (GLWD) - Level 3 35
Map 31: Rivers in Central Asia (Derived from HydroSHEDS) – FAO databases 36
Map 32: World linear water and world water bodies –ESRI database 37
Map 33: Potential area for out-scaling raised bed technology within the irrigated areas. 38
Map 34: Potential area for out-scaling raised bed technology and the proximity to perennial water sources 39
Map 35: Potential area for out-scaling conservation agriculture within the rainfed agroecosystem. 40
Map 36: Potential area for out-scaling mountain agro-forestry 41
Map 37: Potential area for out-scaling pasture improvement within the rangeland agro-ecosystem (slope degree > 12) 42
Map 38: Potential area for out-scaling pasture improvement with slope degree < or = 12. 43
Map 39: Potential area for out-scaling pasture improvement (all slope classes) 43
Map 40: Simialr areas for the four agro-ecosystem (areas with slope more than 12 degree for rangeland) 44
Map 41: Simialr areas for the four agro-ecosystem (areas with slope less than or equal 12 degree for rangeland) 44
Map 42: Large scale irrigation areas (used from LADA project) and irrigated areas layer received from Uzbekistan 47
Map 43: Irrigated layer shows some water bodies and population 47
Map 44: Land use layers received from Kazakhstan 48
Map 45: Land use layers received from Kyrgyzstan 49
Map 46: Land use layers received from Uzbekistan 49

Map 47: Land use layers received from Tajikistan 50
Map 48: New land use layer for the irrigated agro-ecosystem 51
Map 49: New land use layer for the rainfed agro-ecosystem 51
Map 50: Areas with altitude 800 – 3000 m 52
Map 51: Potential area for out-scaling raised bed technology within the irrigated agro-ecosystem 53
Map 52: Potential area for out-scaling conservation agriculture within the rainfed agro-ecosystem 54
Map 53: Potential area for out-scaling mountain agro-forestry within the mountain agro-ecosystem 55
Map 54: Potential area for out-scaling pasture improvement within the rangeland agro-ecosystem 56
Map 55: Potential areas for out-scaling deifferent SLM technologies within four agro-ecosystems in Central Asia (Irrigated, Rainfed, Rangeland and Mountain). 57

List of Tables

Table 1: Similarity criteria for selected SLM technologies in each target agro-ecosystem 9
Table 2: Selected criteria and data sources used for similarity analysis 10
Table 3: Selected criteria and raster data resoultions used for similarity analysis 11
Table 4: Area and population percentages in land degradation classes (excluding bare, urban and water areas) for world 17
Table 5: Sources of land use data 19
Table 6: Land use classes chosen to represent the rangeland areas 22
Table 7: Classification of soil texture by Kachinsky 27
Table 8: Diameter limits for soil textures accoridng to USDA classification 27
Table 9: Agronomic relevant limits 31
Table 10: Data sources for the defining the potential areas for out-scaling raised-bed technology within the Irrigated agro-ecosystem 38
Table 11: Data sources for the defining the potential areas for out-scaling conservation agriculture within the rainfed agro-ecosystem 40
Table 12: Data sources for the defining the potential areas for out-scaling agro-forestry technologies within the mountain agro-ecosystem 41
Table 13: Data sources for the defining the potential areas for out-scaling pasture improvement technologies within the rangelands agro-ecosystem 42
Table 14: Modified similarity criteria for selected SLM technologies in each target agro-ecosystem...... 45
Table 15: National data used for fine-tuning similarity maps 48

List of Figures

Figure 1: Combination of the biophysical status index with the biophysical degradation index 17
Figure 2: Precipitation histogram 25
Figure 3: Texture classes in HWSD 28
Figure 4: Similarity analysis results: calcualtion of total area (km^2) of each agro-ecosystem 58
Figure 5: Similar area percentage in each Central Asian Countries for each agro-ecosystem 58

List of Appendixes

Appendix 1: list of SLM technologies classified per target agro-ecosystem 60
Appendix 2: Core technologies and technologies options to integrate into core technology 62
Appendix 3: Land use system classes by LADA project 64
Appendix 4: List of participants 65

Introduction

Land degradation is a serious economic, social, and environmental problem in the transition economies of the central Asia Countries of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. It directly affects the livelihood of the rural population by reducing the productivity of land resources and adversely affecting the stability, functions, and services derived from natural systems. Agricultural yields are reported to have declined by 20-30 percent across the region since these countries achieved independence few a decades ago, annual losses of agricultural production from soil salinization alone are reportedly estimated as much as US$2 billion. The causes of land degradation are multiple, complex, and vary across these countries, but are largely attributable to the abuse and over-exploitation of the natural resource base, particularly through inappropriate and unsustainable agricultural practices, overgrazing, deforestation, forest degradation, and natural disasters. The principal forms and causes of land degradation currently experienced across the Central Asian countries include (1) erosion, salinization and water logging; (ii) deteriorating productivity of rangelands; (iii) decrease in fertility of the arable drylands of the steppes; (iv) decreased area and productivity of forests; (v) on-site and off-site impacts of mining operations; (vi) exacerbated risks from landslides and flooding due to poor watershed management; (vii) reduced stability and functioning of desert, mountain, wetland, and riparian ecosystems; and (viii) inadequate and incorrect assessment and monitoring of land degradation. The goal of Central Asian Countries Initiative for Land Management (CACILM) is to combat land degradation while improving rural livelihoods across the region in close partnership and support of national governments and international organizations. Projects that fall under the CACILM support the following objectives: capacity building for mainstreaming sustainable land management (SLM) and ensuring integrated SLM planning and management; development of an SLM information system; SLM research; information dissemination and ***knowledge management (ADB, 2006).*** (Bank, 2006)

<u>The knowledge management in CACILM phase II</u>: is a diverse and operational partnership to address SLM in Central Asia, it is a logical continuation of earlier SLM-research conducted by ICARDA and other projects conducted within CACILM phase I. The project team collected and synthesized SLM technologies and approaches utilizing various sources that cover four target agro-ecosystems (irrigated, mountain, rainfed and rangeland). Collected SLM were prioritized during regional level workshop in Almaty, Kazakhstan (February 25-27, 2014). The regional workshop was preceded by the national level workshops in each of the countries where SLM were collected, synthesized, found fit for the environmental conditions of particular country and were evaluated and preliminarily shortlisted (see Appendix 1). Since there were several SLM technologies from country teams that had similarities (for instance minimizing mechanical disturbance of the soil, field level irrigation water saving, improvement of soil conditions, integration of agroforestry, pasture improvement etc.) and addressed specific issues within certain technology it was decided to form a package for each agro-ecosystem. Each package has a core technology (i.e. raised bed in irrigated agro-ecosystem) and other technologies that could be associated with the core technologies, which help in adapting to local conditions within the context of the core technology. For example, seed treatment or soil additive, integration of plastic lining for irrigation in the furrow or placement of the seeding row can be integrated with the raised-bed technology to overcome damage from soil salinity accumulation.

As a result of consultation with national experts from the five countries, during a regional workshop, a list of similarity criteria were identified for the four agro-ecosystems. The similarity maps will be used to identify target areas to disseminate the SLM packages in the four agro-ecosystems. These areas will be also targeted for knowledge management and dissemination campaigns. The methodology and result of the preliminary similarity analysis, data collection constraints were shared with the national teams. This report summarizes results of the similarity analysis.

Similarity Criteria

Based on the formulated SLM packages, similarity criteria (Table 1) were suggested by the national experts from the five countries to develop similarity maps. The process was facilitated using previous experience of similarity analysis and criteria undertaken in the West Asia and North Africa (WANA) region (F. Ziadat, 2014). The brainstorming round identified sets of criteria and indicators that were used to generate preliminary similarity maps on regional level. The purpose of this regional level similarity map generation exercise is to present data and procedure for fine-tuning at country level by the national experts.

Table 1: Similarity criteria for selected SLM technologies in each target agro-ecosystem

Irrigated agro-ecosystem / Potential area for out-scaling raised bed technology	**Similarity criteria**
Land use	Irrigated land
Slope, degree	0-5
Water availability/source	Sufficient water resources
Soil (texture), clay content, %	10-75 physical clay
Soil salinity, %	*< 8 dS m^{-1}*

Rainfed agro-ecosystem / Potential area for out-scaling conservation agriculture	**Similarity criteria**
Precipitation	300-600
Slope, degree	<7
Land use	Cropland
Soil (texture), clay content, %	20-75 physical clay

Mountain agro-ecosystem / Potential area for out-scaling mountain agro-forestry	**Similarity criteria**
Slope, degree	>7
Precipitation	>500
Altitude, m	>800
Land use	exclude inconvinient areas (rocks, gullies etc.)
Soil depth, cm	>50

Rangelands agro-ecosystem / Potential area for out-scaling pasture improvement	**Similarity criteria**
Land use	rangelands, pasture
Slope, degree	>12
Degradation degree	**Areas with weak, medium to strong degradation as well as the Bareland areas**
Livestock density per ha	**Areas with high and moderate livestock density**
Watering points/ha	**Data not available**

To run the similarity analysis, data to satisfy the similarity criteria were collected, processed and prepared to suit the multi-criteria analysis. The following section details the sources of different data as well as the pre-analysis processing. This is to ensure the reproducibility of this analysis by different stakeholders within and beyond the Central Asian region.

Data sources and data preparations

Data sources

To conduct the similarity analysis, different spatial datasets were needed. Available online data sources were used to obtain spatial datasets, the following Table 2 shows data required with the data source used. Note that other data sources are available but these data were chosen due to their relevance and suitability to the analysis.

Table 2: Selected criteria and data sources used for similarity analysis

Criteria	Data Sources
Altitude, m and Slope, degree	***The Consultative Group on International Agricultural Research (CGIAR), Consortium for Spatial Information (CGIAR-CSI), SRTM 90 Digital Elevation Data*** http://srtm.csi.cgiar.org/
Degradation degree	**Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), Global Land Degradation Information System (GLADIS) - Simplified output, Classes of land degradation** http://www.fao.org/nr/lada/gladis/glad_ind/
Land use	**Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), Global Land Degradation Information System (GLADIS), Land use systems of the world - v1.1** http://www.fao.org/nr/lada/gladis/lus/ ***Food and Agriculture Organization*** **of the United Nation** ***(FAO), Effective Soil Depth (cm) Map, Class 10*** http://data.fao.org/map?entryId=c3bfc940-bdc3-11db-a0f6-000d939bc5d8
Livestock density per ha	**Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), GLADIS Global Land Degradation Information System - Beta version Livestock density** http://www.fao.org/nr/lada/gladis/lus/
Precipitation	***WorldClim – Global Climate Data*** http://www.worldclim.org/download
Soil Data Soil (texture), clay content, % Soil depth, cm Soil salinity, %	***Harmonized World Soil Database (HWSD) - (version 1.2)*** http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/ ***Food and Agriculture Organization – GeoNetwork, Digital Soil Map of the World*** http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116
Water availability/source	***World Wide Fund for Nature (WWF), Conservation Science Data and Tools, Global Lakes and Wetlands Database*** Http://worldwildlife.org/pages/global-lakes-and-wetlands-database ***Food and Agriculture Organization*** **of the United Nation** ***(FAO), Global Water Information System AQUASTAT*** Http://www.fao.org/nr/water/aquastat/main/index.stm ***Economic and Social Research Institute (ESRI); World Water Bodies and World Linear Water*** http://www.arcgis.com/home/item.html?id=e750071279bf450cbd510454a80f2e63 and http://www.arcgis.com/home/item.html?id=273980c20bc74f94ac96c7892ec15aff
Watering points/ha	**available only for Uzbekistan**

Data preparations

The data sources were downloaded from specific websites as in Table 2. The following section describes the data used and the procedures used to prepare the layers needed for the similarity analysis. Most of the data available is in raster format with different resolutions, and to conduct the similarity analysis the layers should be in the same pixel size Table 3.

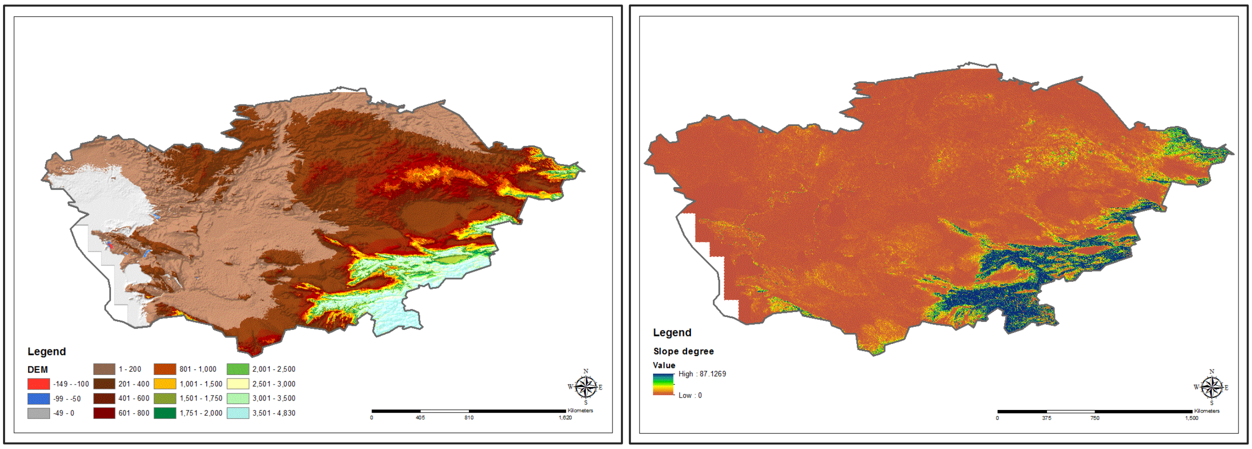
Table 3: Selected criteria and raster data resoultions used for similarity analysis

Criteria	Data Source(s)	Raster resolution Cell size(x, y)
Altitude, m And Slope, degree	The Consultative Group on International Agricultural Research (CGIAR), Consortium for Spatial Information (CGIAR-CSI), SRTM 90 Digital Elevation Data http://srtm.csi.cgiar.org/	(90, 90) m
Degradation degree	Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), GLADIS Global Land Degradation Information System - Beta version http://www.fao.org/nr/lada/gladis/glad_ind/	(9, 9) Km
Land use	Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), GLADIS Global Land Degradation Information System - Beta version, Land use systems http://www.fao.org/nr/lada/gladis/lus/	(9, 9) Km
Livestock density per ha	Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), GLADIS Global Land Degradation Information System - Beta version Livestock density http://www.fao.org/nr/lada/gladis/lus/	(9, 9) Km
Precipitation	WorldClim – Global Climate Data http://www.worldclim.org/download	(1, 1) Km
Soil Data Soil (texture), clay content, % Soil salinity, %	Harmonized World Soil Database (HWSD) - (version 1.2) http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/	(1, 1) Km

Digital Elevation Data

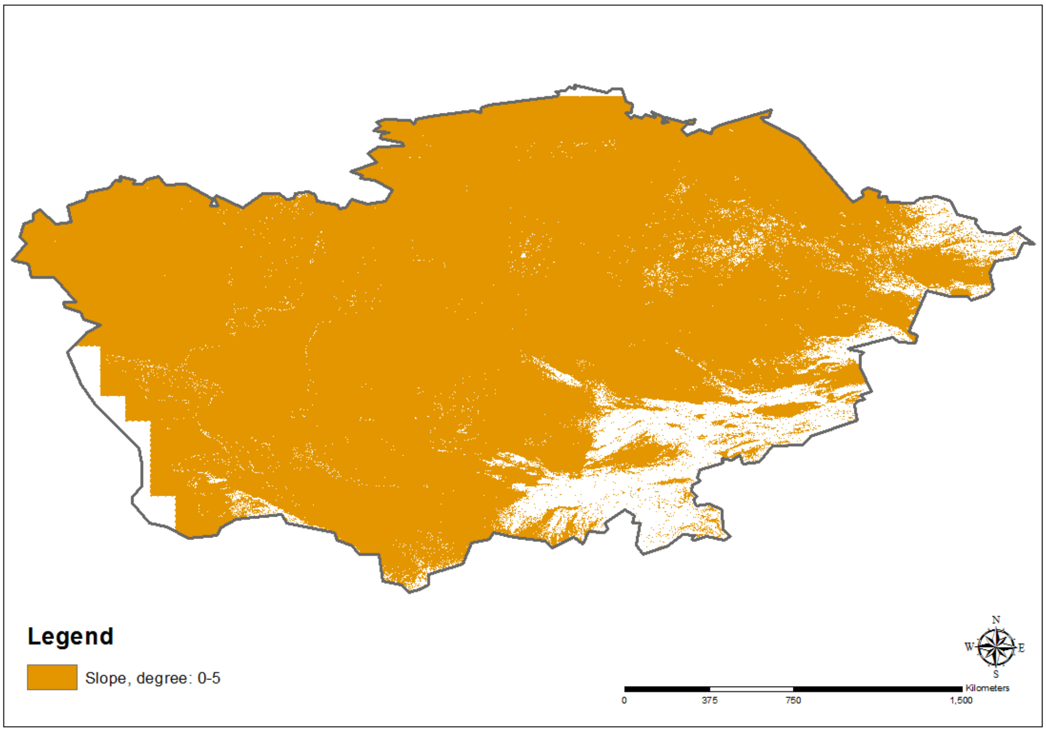
The digital elevation model (DEM) was downloaded from the CGIAR CSI website. The CGIAR CSI geo-portal provides shuttle radar topography mission (SRTM) 90 m digital elevation data for the entire world. The SRTM digital elevation data, produced originally by NASA, is a major breakthrough in digital mapping and provides a major advance in the accessibility of high quality elevation data for large portions of the tropics and other areas of the developing world. Obtained SRTM digital elevation data has already been processed to fill data voids and to facilitate ease of use by a wide group of potential users. This data is provided in an effort to promote the use of geospatial science and applications for sustainable development and resource conservation in the developing world. The SRTM 90 m DEM's have a resolution of 90 m at the equator, and are provided in mosaicked 5° x 5° tiles for easy download and use. All are produced from a seamless dataset to allow easymosaicking. These are available in both ArcInfo ASCII and GeoTiff format to facilitate their ease of use in a variety of image processing and GIS applications.

The NASA SRTM has provided DEM data for over 80% of the globe. This data is currently distributed free of charge by USGS and is available for download from the National map seamless data distribution system, or the USGS ftp site. The SRTM data is available as 3 arc second (approximately 90 m resolution) DEMs. A 1 arc second data product was also produced, but it is not available for all countries. The vertical error of the DEM is reported to be less than 16 m. The data currently distributed by NASA/USGS (finished product) contains 'no-data' holes where water or heavy shadow prevented the quantification of elevation. These are generally small holes, which nevertheless render the data less useful, especially in the field of hydrological modeling. In order to have a DEM for the study area, the SRTM 90 m DEMs for 37 geographical sections were downloaded. All these sections were then mosaicked into one raster and this raster clipped to the study area (Map 1). The DEM used to generate the altitude (m) which is needed for the mountain agro-ecosystem and the slope degree for the four agro-ecosystem, the DEM has a spatial reference of (GCS_WGS_1984) the raster was re-projected to a geographic coordinate system (WGS_1984_UTM_Zone_41N) to create the slope degrees for Central Asian countries (Map 1).

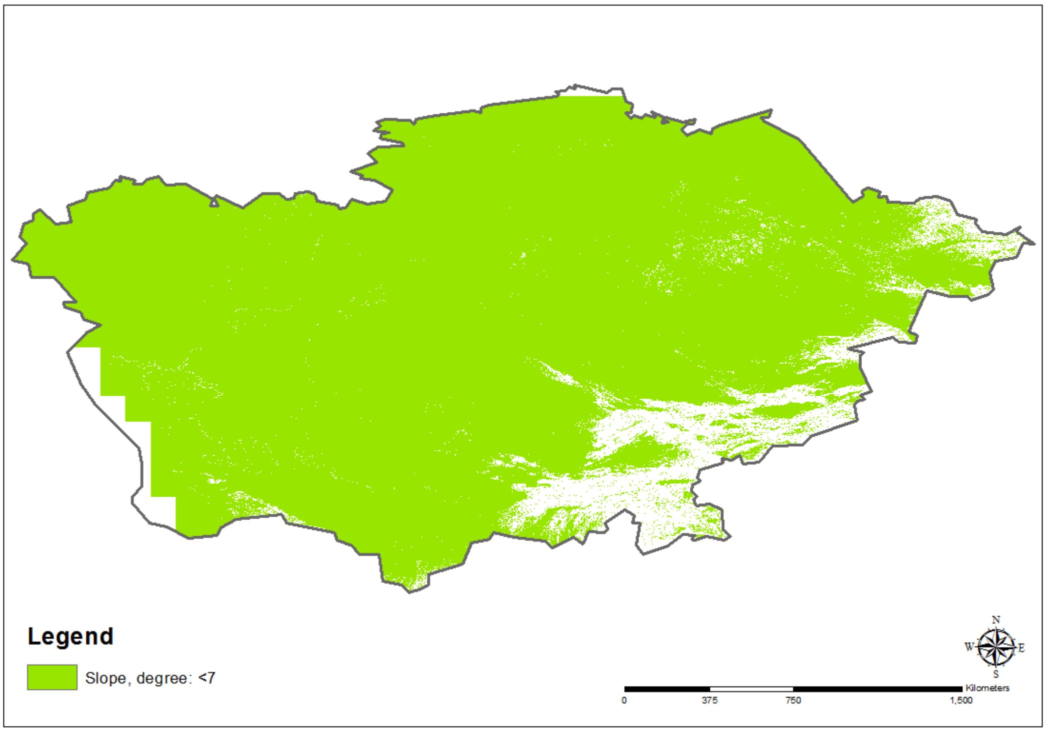


Map 1: Digital elevation model and slopes in Central Asia

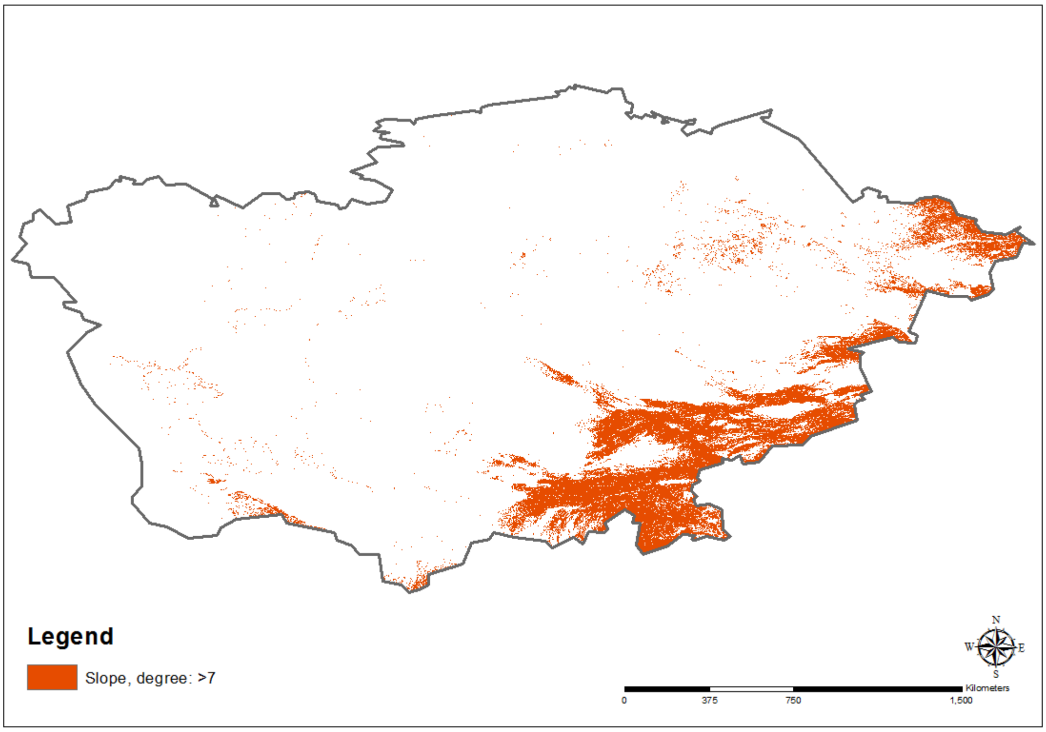
For each agro-ecosystem a specific slope is required. Maps below show the slopes required for each agro-ecosystem:



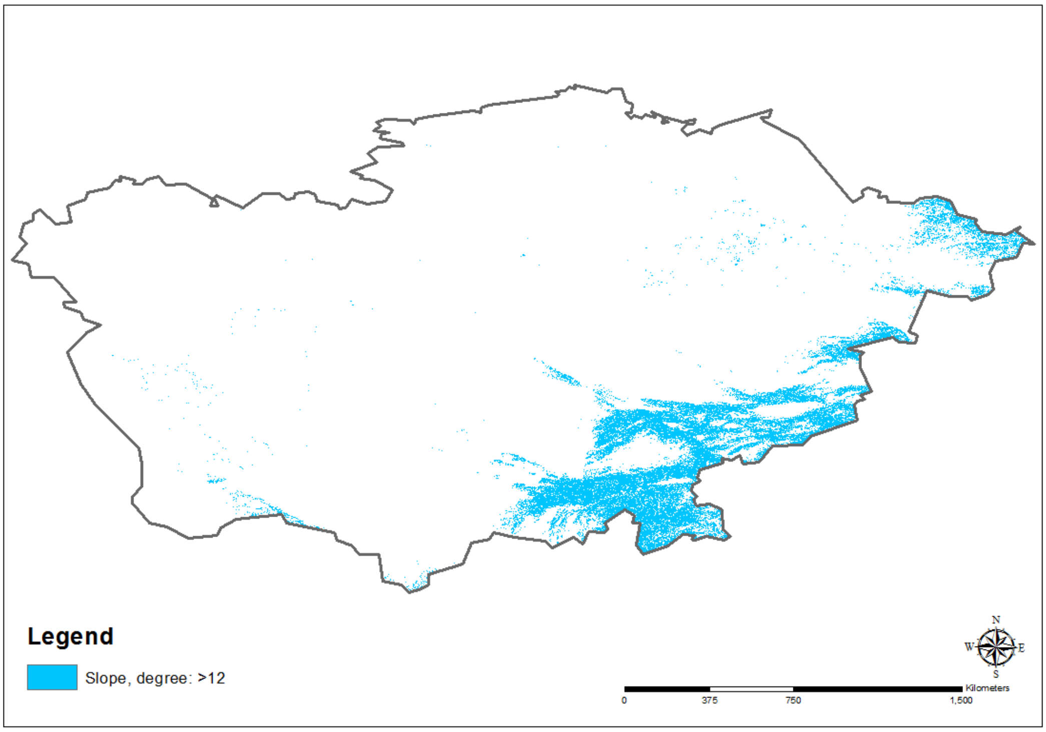
Map 2: Slope degree required for irrigated agro-ecosystem



Map 3: Slope degree required for rainfed agroecosystem

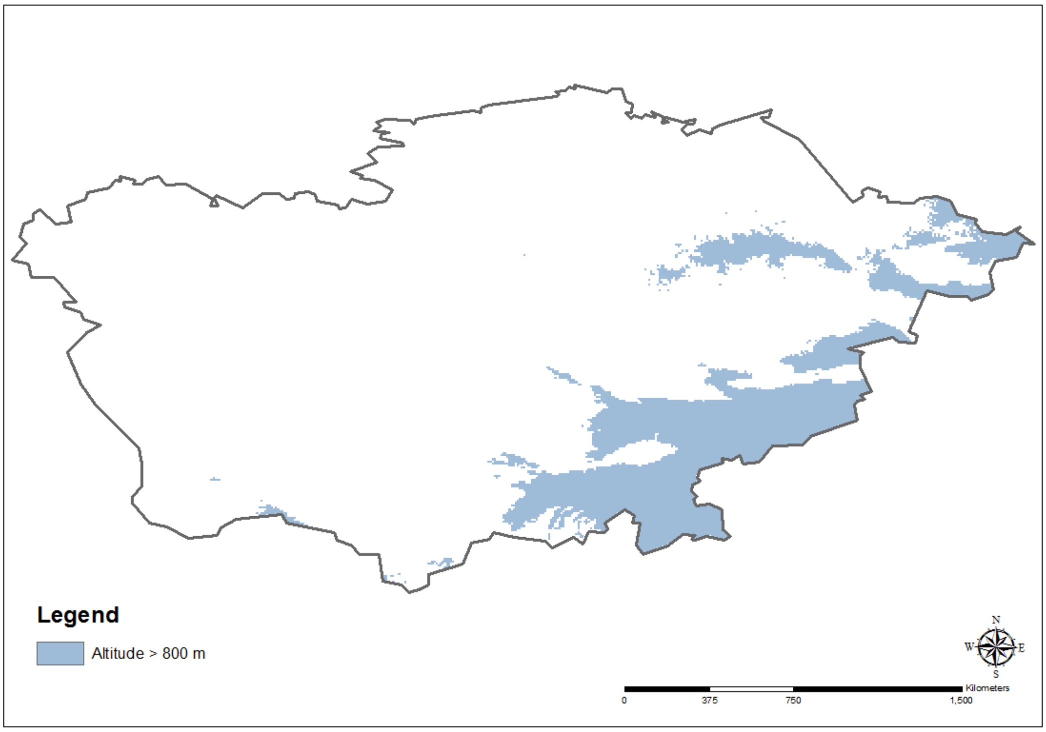


Map 4: Slope degree required for mountain agro-ecosystem



Map 5: Slope degree required for the potential area for out-scaling pasture improvement (Slope degree >12) – Option 1

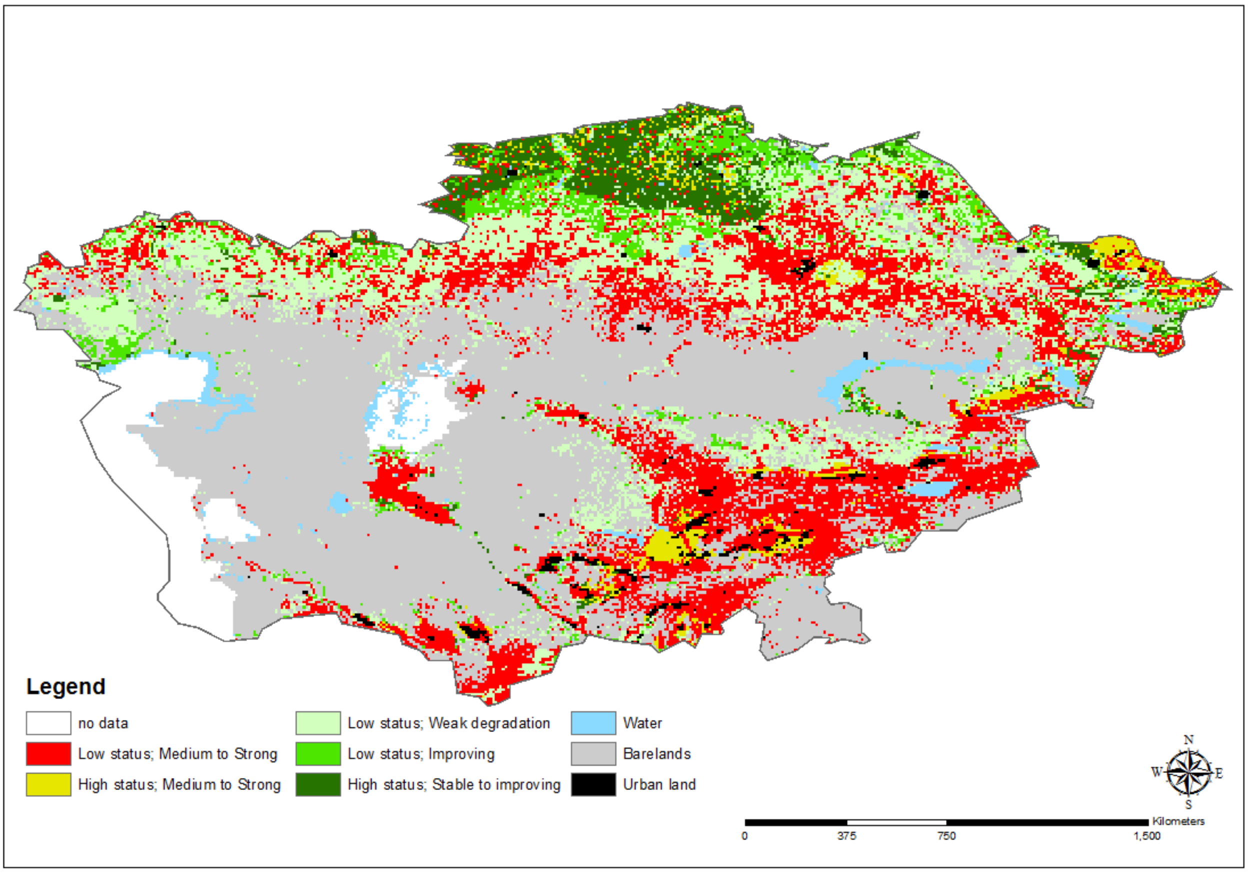
The DEM was also used to derive the altitude data which is needed for the mountain agro-ecosystem.



Map 6: Areas with altitude > 800 m

Land degradation

The source of land degradation data is the result of the Land Degradation Assessment in Dryland (LADA) project. LADA report classified land degradation into five classes as shown in Map 7, this map describes the overall status in provision of biophysical ecosystem services and the processes of declining biophysical ecosystem services by considering the combined value of each biophysical axis (biomass, soil, water and biodiversity). The combined reclassification is provided in Figure 1. A global synthesis of the outcome is presented in Table 4 showing the 32% of land is in areas with high provision of biophysical goods and services status, but with medium to strong degradation processes, while the largest part of the population 27% live in areas with a low status of biophysical goods and services provision and a medium to strong degradation (Freddy O. Nachtergaele, 2011).



Map 7: Land degradation classes

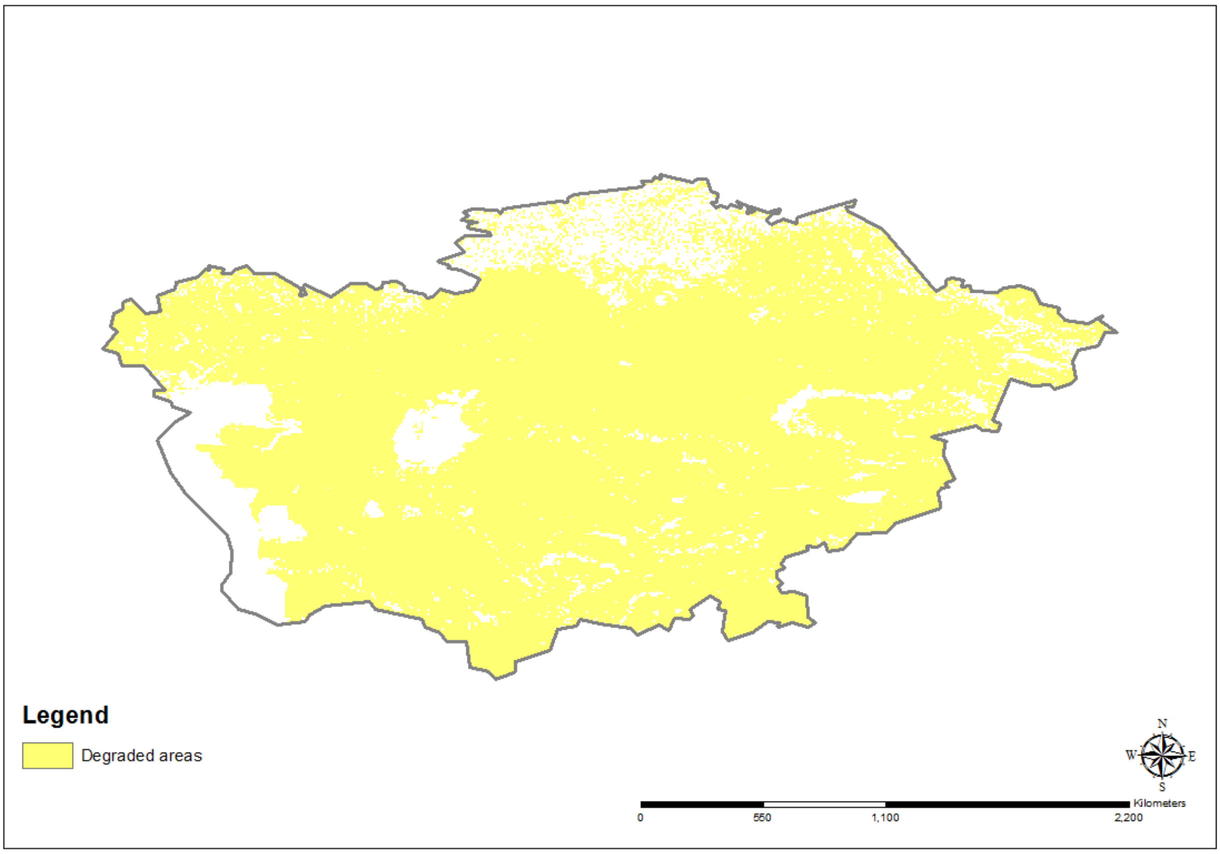
		Status			
		<=25 bad	25-49.99	50-75	>75 good
Process	>0.7 high LD process	Low status; Medium to Strong degradation	Low status; Medium to Strong degradation	High status; Medium to Strong degradation	High status; Medium to Strong degradation
	0.5-0.7	Low status; Medium to Strong degradation	Low status; Medium to Strong degradation	High status; Medium to Strong degradation	High status; Medium to Strong degradation
	0.5-0.55	Low status; Weak degradation	Low status; Weak degradation	High status; Stable to improving	High status; Stable to improving
	<= 0.5 low LD process	Low status; Improving	Low status; Improving	High status; Stable to improving	High status; Stable to improving

Figure 1: Combination of the biophysical status index with the biophysical degradation index

Table 4: Area and population percentages in land degradation classes (excluding bare, urban and water areas) for world

Land degradation classes	Area (%)	Population (%)
Low status, medium to strong	23.1	27.1
High status, medium to strong	32.3	17.5
Low status, weak degradation	13.5	9.1
Low status, improving	3.6	1.4
High status, stable to improving	5.6	3.8

Areas with weak, medium to strong degradation as well as the bareland areas were assumed to represent the degradation level needed for the similarity analysis of the potential area for out-scaling pasture improvement. See (Map 8)



Map 8: Degraded areas including areas with weak, medium to strong degradation as well as bareland areas

Land use

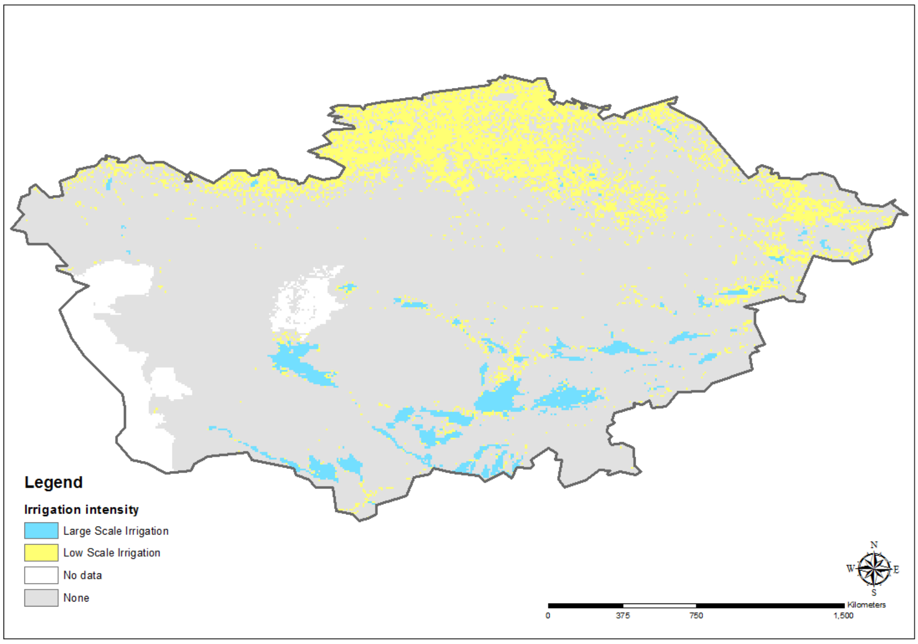
Land use types needed for each agro-ecosystem are varied and data used to extract the specific needed areas are presented in Table 5.

Table 5: Sources of land use data

Agro-ecosystem	Land use criteria	Data source
Irrigated	Irrigated land	**Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), Global Land Degradation Information System (GLADIS), Land use systems of the world - v1.1, irrigation intensity.** http://www.fao.org/nr/lada/gladis/lus/
Rainfed	Cropland	**Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), Global Land Degradation Information System (GLADIS), Land use systems of the world - v1.1, dominant crops** http://www.fao.org/nr/lada/gladis/lus/
Mountain	Exclude inconvenient areas (rocks, gullies etc.)	***Food and Agriculture Organization (FAO), Effective Soil Depth (cm) Map, Class 10*** http://data.fao.org/map?entryId=c3bfc940-bdc3-11db-a0f6-000d939bc5d8
Rangelands	Rangelands, pasture	**Food and Agriculture Organization of the United Nation (FAO), The Land Degradation Assessment in Drylands project (LADA), Global Land Degradation Information System (GLADIS), Land use systems of the world - v1.1, land use systems** http://www.fao.org/nr/lada/gladis/lus/

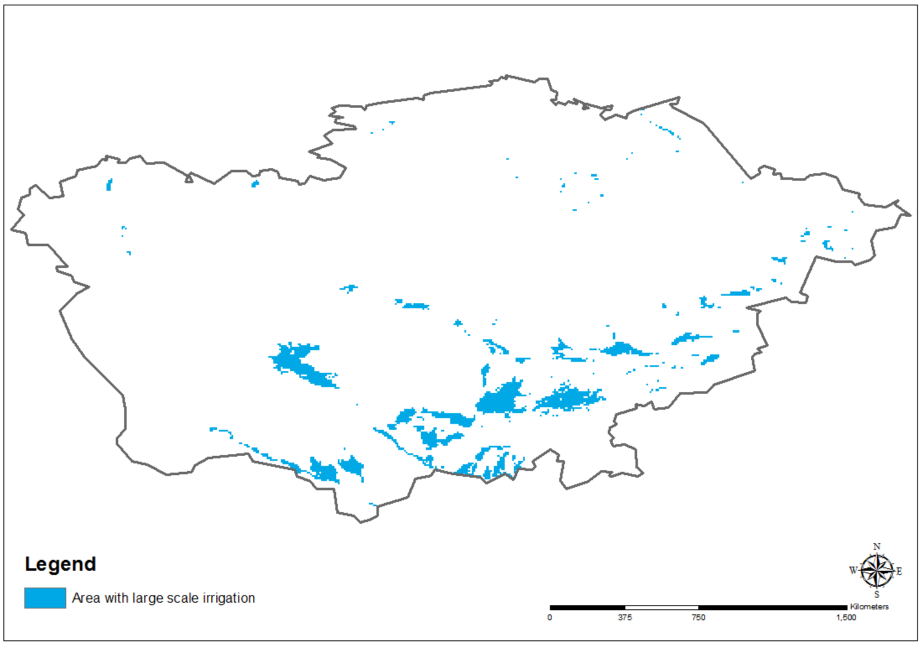
The following maps show the land use classification from the data sources:

1. Irrigation intensity map that reflects the irrigated areas:



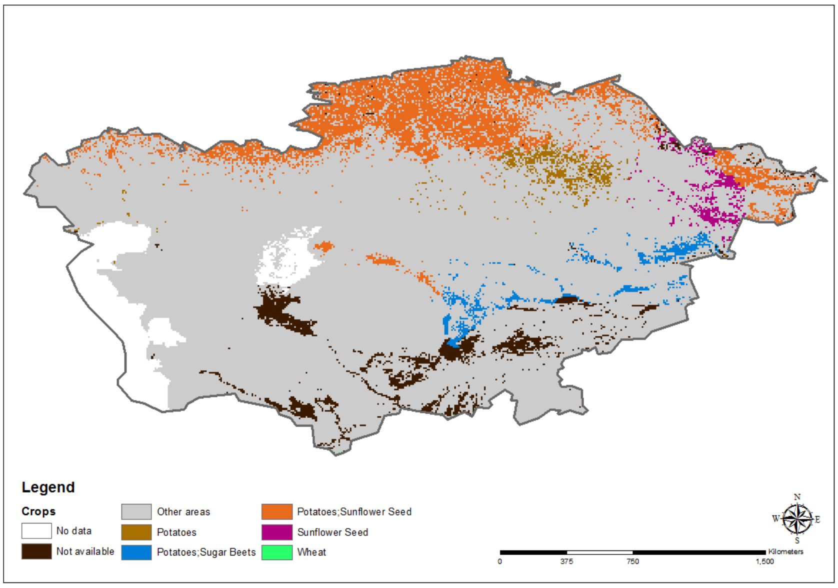
Map 9: Data used to identify the land use criteria for irrigated agro-ecosystem

Large scale irrigated areas is used to present the land use criteria required for irrigated agro-ecosystem similarity analysis. See (Map 10)



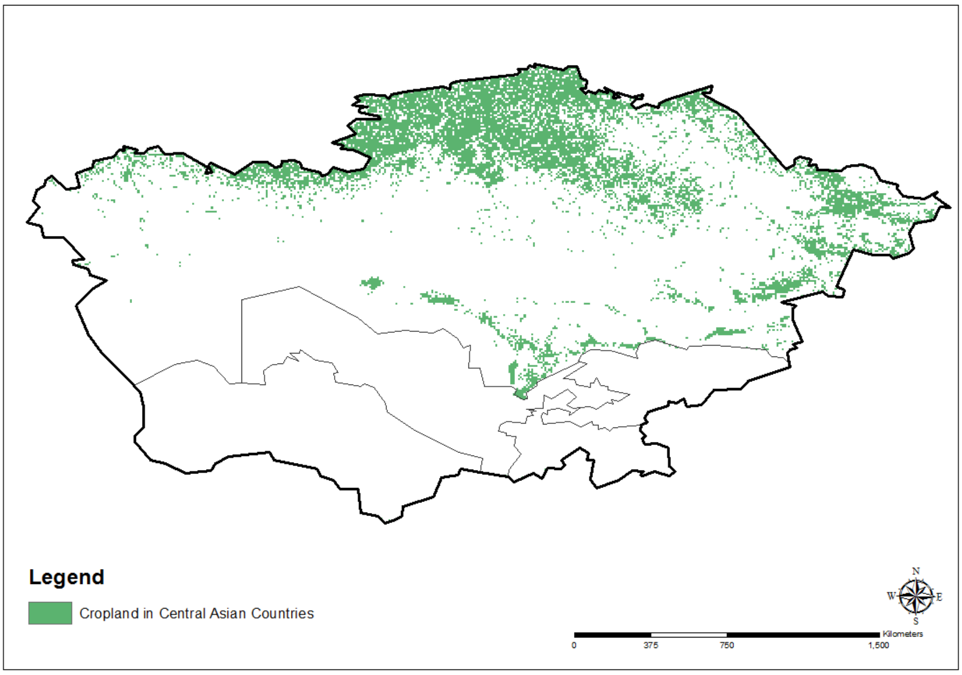
Map 10: Area with large scale irrigation

2. Crops map shows crops types and distribution :



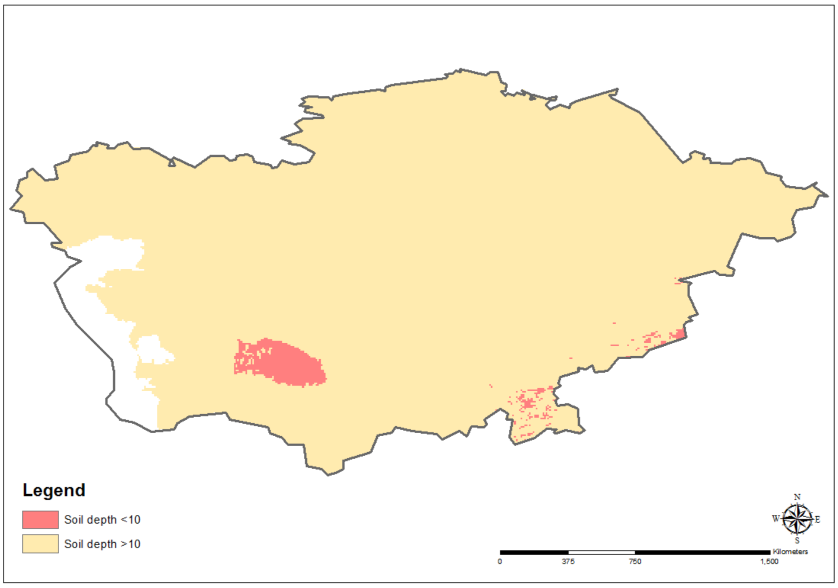
Map 11: Data used to identify the land use criteria for rainfed agro-ecosystem

Only areas with crops are used to conduct the similarity analysis for the rainfed agro-ecosystem. See (Map 12)



Map 12: Crop area in Central Asian countries

3. We assume that areas that do not include rocks are areas where the soils depth is over 10 cm deep:

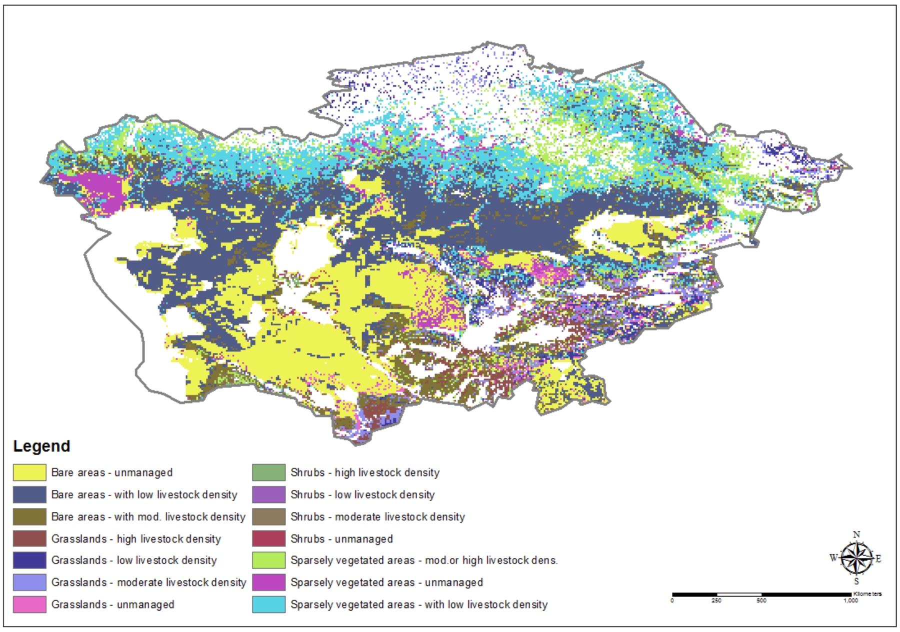


Map 13: Data used to identify the land use criteria for mountain agroecosystem

3. Rangeland or pasture area selected from the land use system classes used in LADA project. See Appendix 3. See Table 6, these areas were considered as rangeland area within Central Asian countries, see (Map 14).

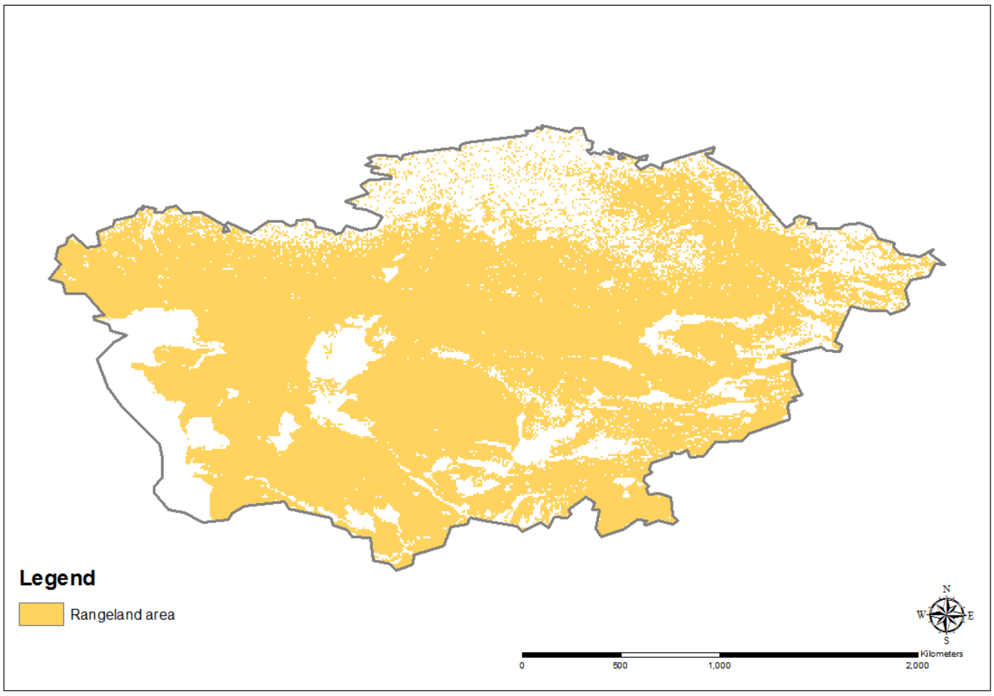
Table 6: Land use classes chosen to represent the rangeland areas

No	Land use classes
1.	Bare areas - unmanaged
2.	Bare areas - with low livestock density
3.	Bare areas - with mod. livestock density
4.	Grasslands - high livestock density
5.	Grasslands - low livestock density
6.	Grasslands - moderate livestock density
7.	Grasslands - unmanaged
8.	Shrubs - high livestock density
9.	Shrubs - low livestock density
10.	Shrubs - moderate livestock density
11.	Shrubs - unmanaged
12.	Sparsely vegetated areas - mod. or high livestock dens.
13.	Sparsely vegetated areas - unmanaged
14.	Sparsely vegetated areas - with low livestock density



Map 14: Data used to identify the land use criteria for rangeland agro-ecosystem

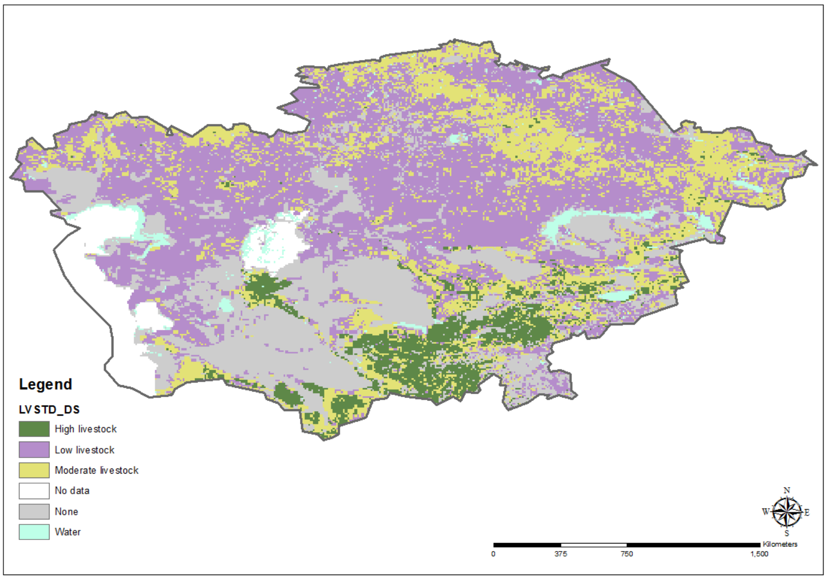
From the above areas, one area created to represent the land use criterion needed for the similarity analysis for the rangeland agro-ecosystem. See (Map 15)



Map 15: Rangeland area

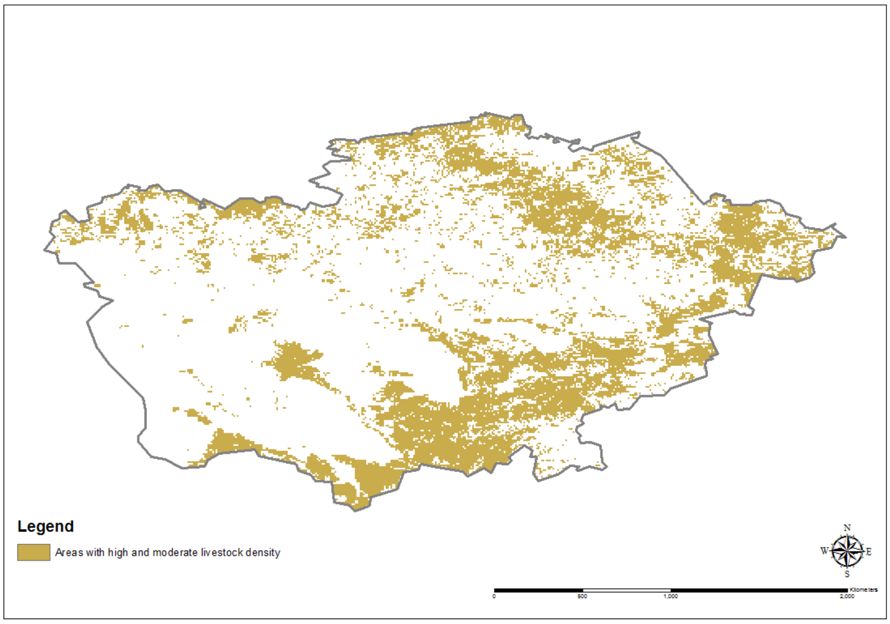
Livestock density

Map 16 shows the distribution of available data from LADA project.



Map 16: Livestock density map

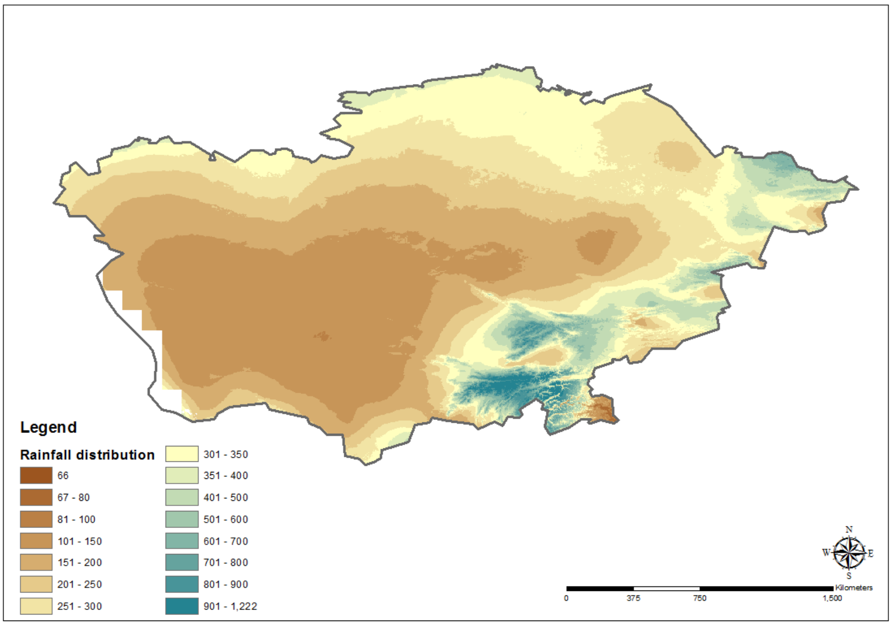
Areas with high and moderate livestock density are chosen for the similarity analysis of the rangeland agro-ecosystem. See (Map 17)



Map 17: Areas with high and moderate livestock density

Precipitation

Data from WorldClim websites was downloaded for two sections that cover Central. The used data is from the current conditions section which is interpolations of observed data, representative of 1950-2000. Data were generated through interpolation of average monthly climate data from weather stations. Data downloaded as a set of 12 raster for each section, a new raster created that represent the average yearly precipitations. Then the two sections where mosaicked and clipped into Central Asian countries area. See (Map 18) and (Figure 2) which shows the minimum average rainfall is 66 mm and the maximum is 1205 mm.



Map 18: Precipitation distribution

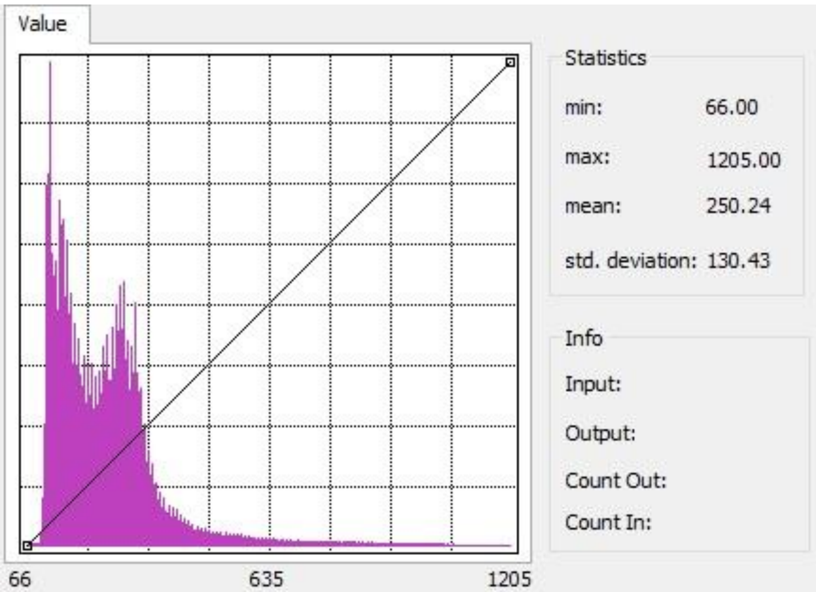
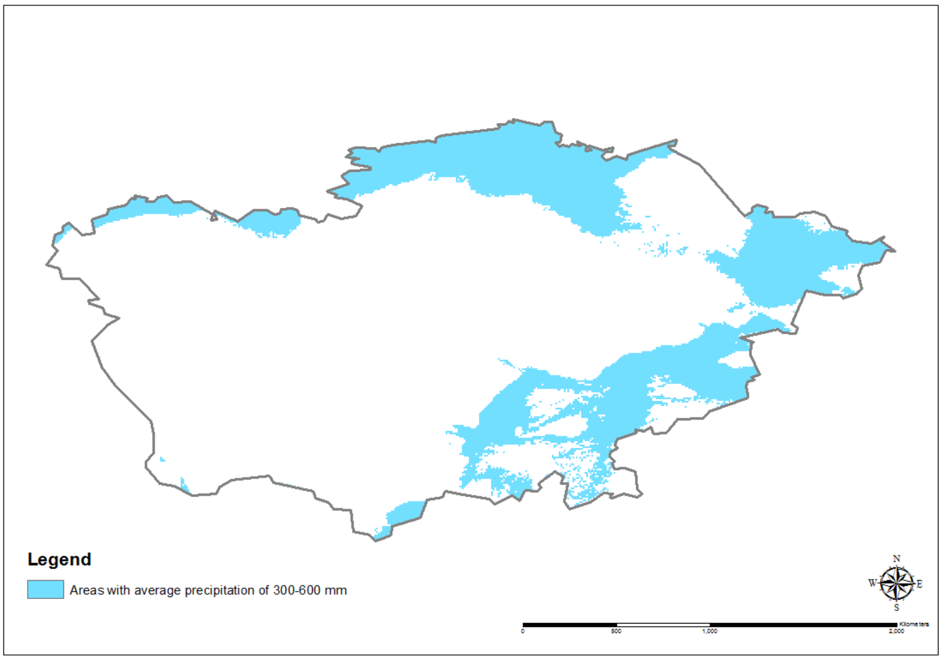
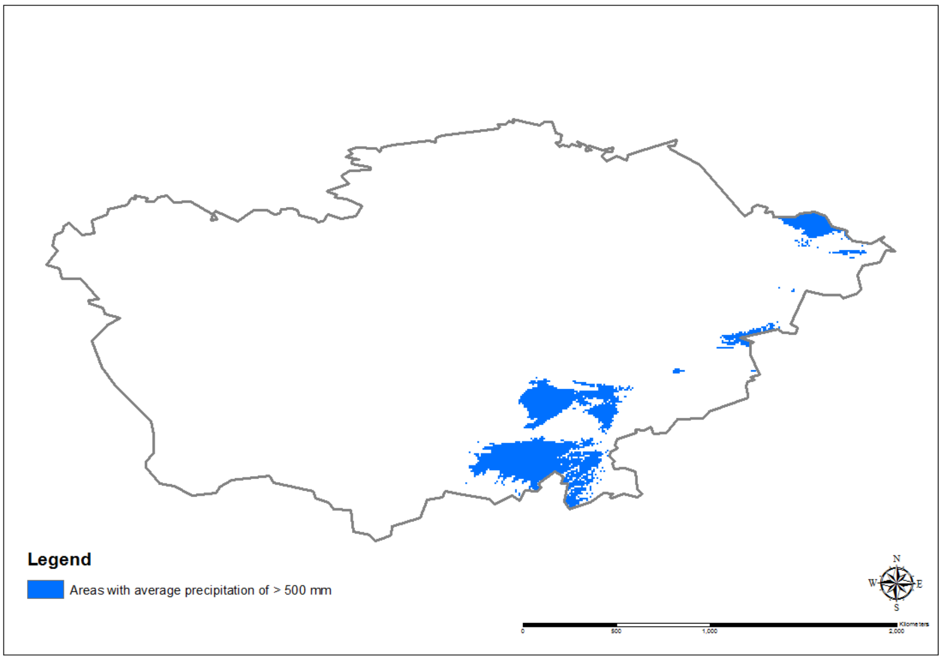


Figure 2: Precipitation histogram

The following shows the areas with average precipitation of 300-600 mm (Map 19) used for rainfed agroecosystem similarity analysis and areas with average precipitation of > 500 mm used for mountain agroecosystem similarity analysis (Map 20).



Map 19: Areas with average precipitation of 300-600 mm - Rainfed Agro-ecosystem



Map 20: Areas with average precipitation of > 500 mm - Mountain Agro-ecosystem

Soil Data

A. Soil Texture

Soil texture (percent of clay content) is needed for the irrigation and rainfed agro-ecosystem. The Russian system for soil texture classification is used in Central Asia and according to this system the soil texture is identified as follow:

"International systems of soil texture vary slightly but are consistent in defining the upper size limit of "clay" particles as 0.002mm. This limit was chosen as marking significant change in the physical and chemical properties of particles greater and less than this limit. Textural classification of soils is based on two-dimensional variation, two out of sand, silt and clay (the third, being defined by the sum equal to 100 percent, is not independent). Although the foundation of the science was by Russian pedologists and Dokuchaev in particular, Kachinsky later adopted different standards to those that became internationally accepted. "Physical clay" (<0.01mm) was the term used in the uni-dimensional Soviet system of textural classification" (Central Asia Water Info) see Table 7.

Table 7: Classification of soil texture by Kachinsky

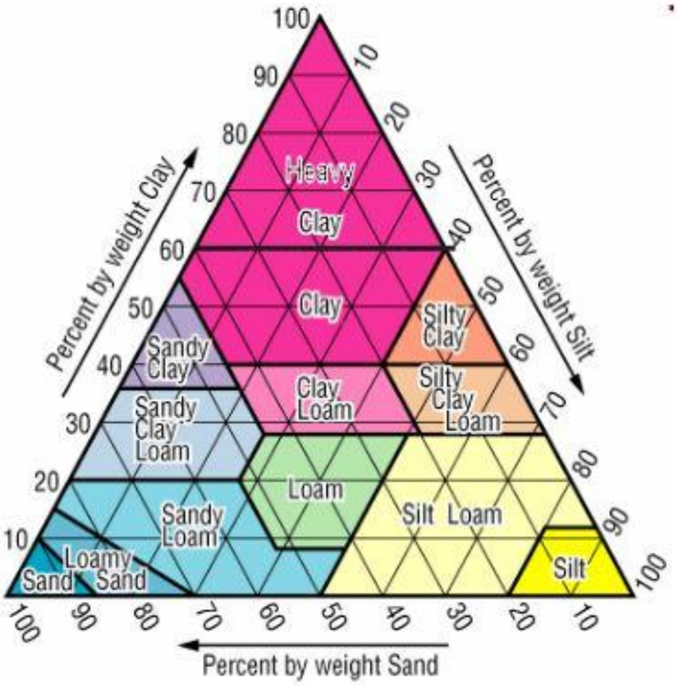
Class	Physical Clay (%)
Clay	>60
Heavy loam	45 - 60
Moderate loam	30 - 45
Light loam	20- 30
Loamy sand	10-20
Sand	<10

The available data source for defining the textural classes is the HWSD. In this reference the soil texture is classified according to the USDA defined as:

"Soil texture is a soil property used to describe the relative proportion of different grain sizes of mineral particles in a soil. Particles are grouped according to their size into what are called soil separates (clay, silt, and sand). The soil texture class (e.g., sand, clay, loam, etc) corresponds to a particular range of separate fractions, and is diagrammatically represented by the soil texture triangle. Coarse textured soils contain a large proportion of sand, medium textures are dominated by silt, and fine textures by clay (http://www.pedosphere.com/resources/bulkdensity/triangle_us.cfm)". See Table 8 and Figure 3.

Table 8: Diameter limits for soil textures accoridng to USDA classification

Soil separates	Diameter limits (mm) (*USDA* classification)
Clay	less than 0.002
Silt	0.002 - 0.05
Sand	0.05 - 2.00



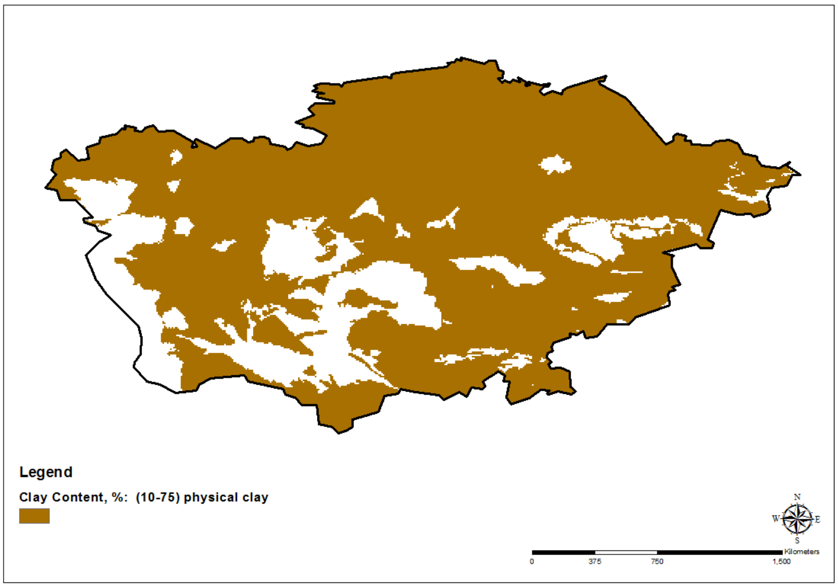
Code	Texture
1	clay (heavy)
2	silty clay
3	clay
4	silty clay loam
5	clay loam
6	silt
7	silt loam
8	sandy clay
9	loam
10	sandy clay loam
11	sandy loam
12	loamy sand
13	sand

Figure 3: Texture classes in HWSD

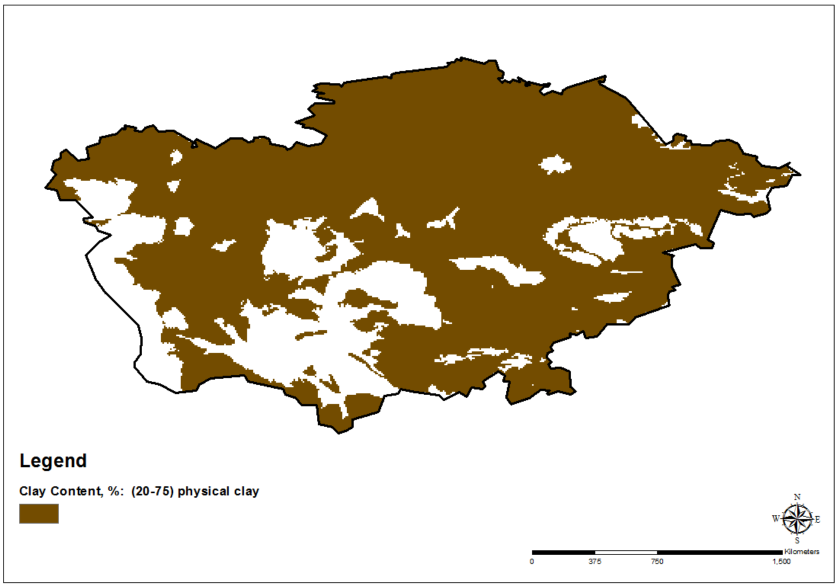
<u>To match the required criteria with the data available the following are categories:</u>

- For the irrigation agro-ecosystem, the percent of physical clay needed for the criteria is (10-75), so class 1 (clay (heavy)) and class 13 (sand) were excluded
- For the rainfed agro-ecosystem, the percent of physical clay needed for the criteria is (20-75), so class 1 (clay (heavy)), class 12 (loamy sand) and class 13 (sand) were excluded.

Areas included the desired percent of physical clay are shown in (Map 21) and (Map 22)



Map 21: Clay content 10%-75% physical clay

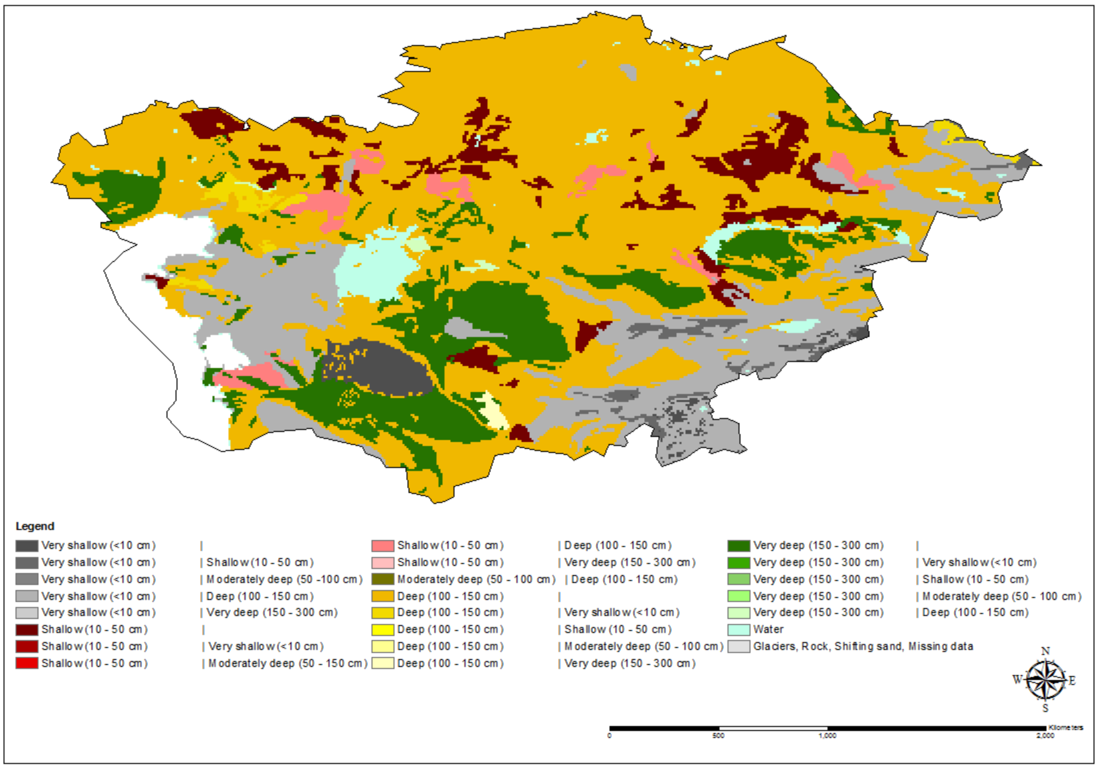


Map 22:Clay Content, %: (20-75) physical clay

B. Soil Depth

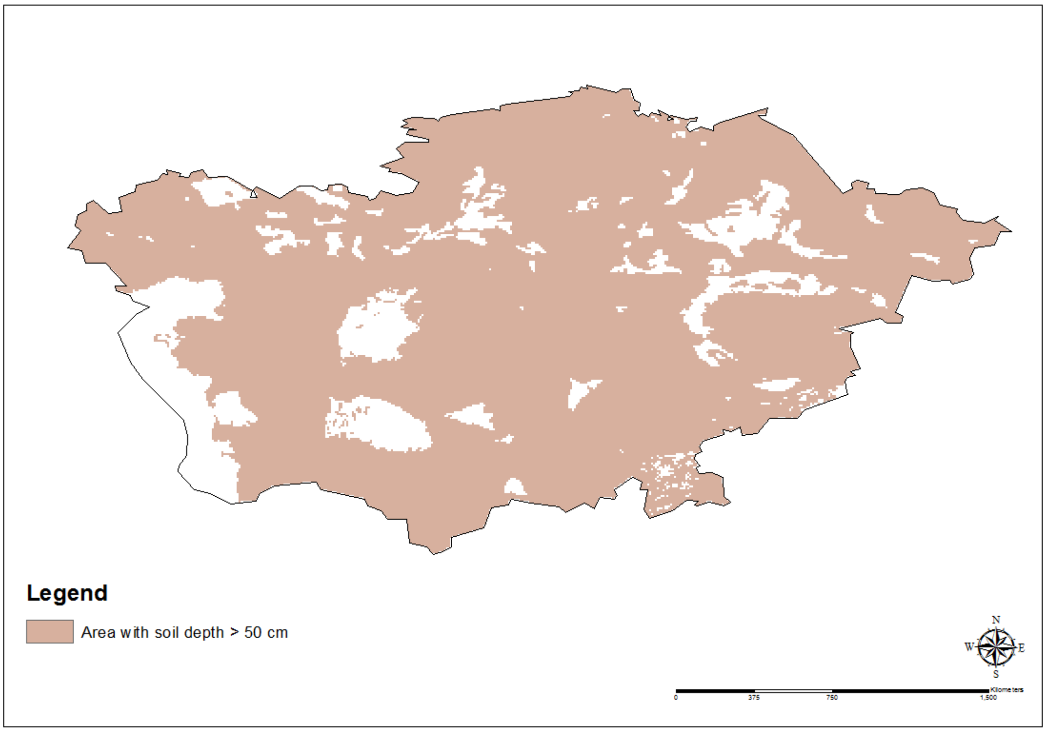
The original data consist of a raster format 'tiff'; the raster is classified into 24 sections. These sections consist of two digits where the first digit indicates the dominant class and the second digit indicates the associated class. All the 24 sections classified the soil depth into the main five classes as follows. See (Map 23).

- 1: Very shallow (< 10 cm)
- 2: Shallow (10–50 cm)
- 3: Moderately deep (50–100 cm)
- 4: Deep (100–150 cm)
- 5: Very deep (150–300 cm)
- 97: Water
- 99: Missing data



Map 23: Soil depth classes in Central Asian countries

The soil depth > 50 cm is a required criterion for the mountain agro-ecosystem. See (Map 24)



Map 24: Area with soil depth > 50 cm

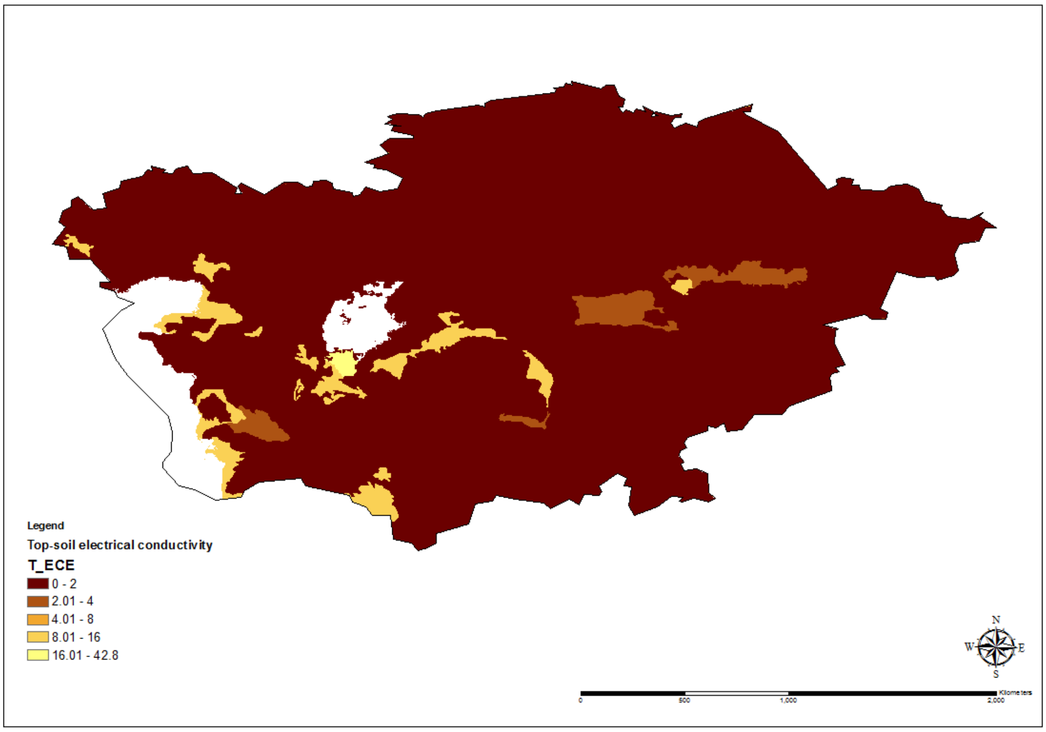
C. *Soil Salinity*

The HWSD included the electrical conductivity of top and sub-soil (see Map 12 and Map 13) this data described as follow:

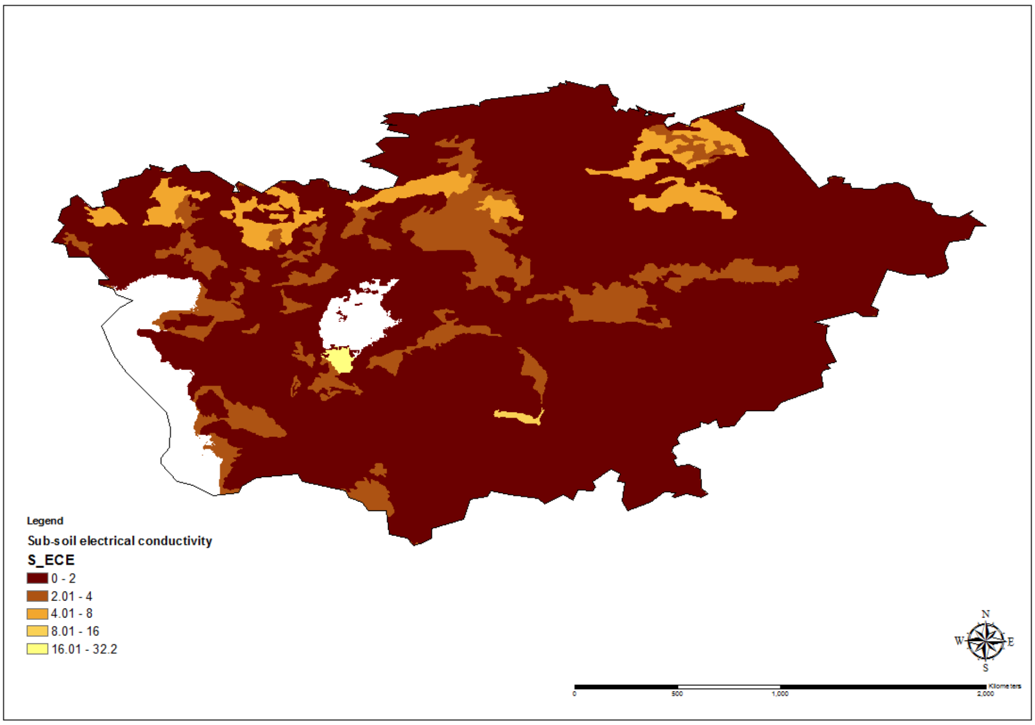
"The salt content of a soil can be roughly estimated from the Electrical Conductivity of the soil (EC, expressed in dSm^{-1}) measured in a saturated soil paste or a more diluted suspension of soil in water. Crops vary considerably in their resistance and response to salt in soils. Some crops will suffer at values as little as 2 dS m^{-1} (Spinach) others can stand up to 16 dS m^{-1} (Date palm)." (FAO/IIASA/ISRIC/ISSCAS/JRC, 2012)

Table 9: Agronomic relevant limits

ECe	**dS m^{-1}**
Very low	< 2
Low	2 – 4
Moderate	4 – 8
High	8 – 16
Very High	> 16

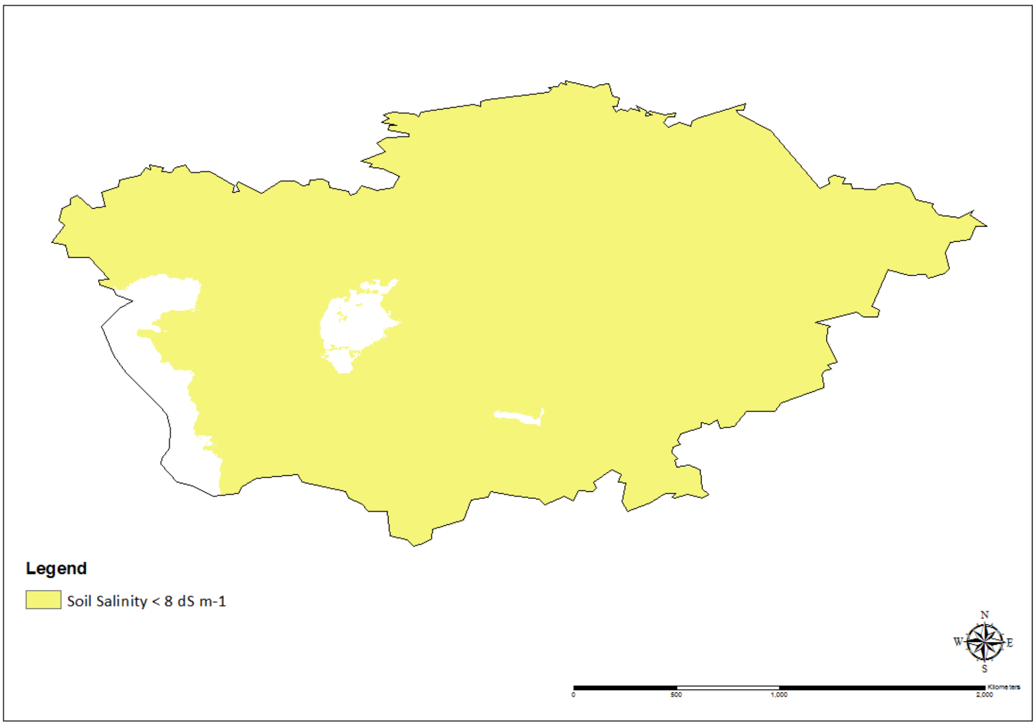


Map 25: Top-soil electrical conductivity



Map 26: Sub-soil electrical conductivity

For the irrigated agro-ecosystem criteria, the non-saline soils are needed, these soils are with electrical conductivity less than 8 dS m^{-1}. See (Map 27)



Map 27: Soil salinity < 8 dS m^{-1}

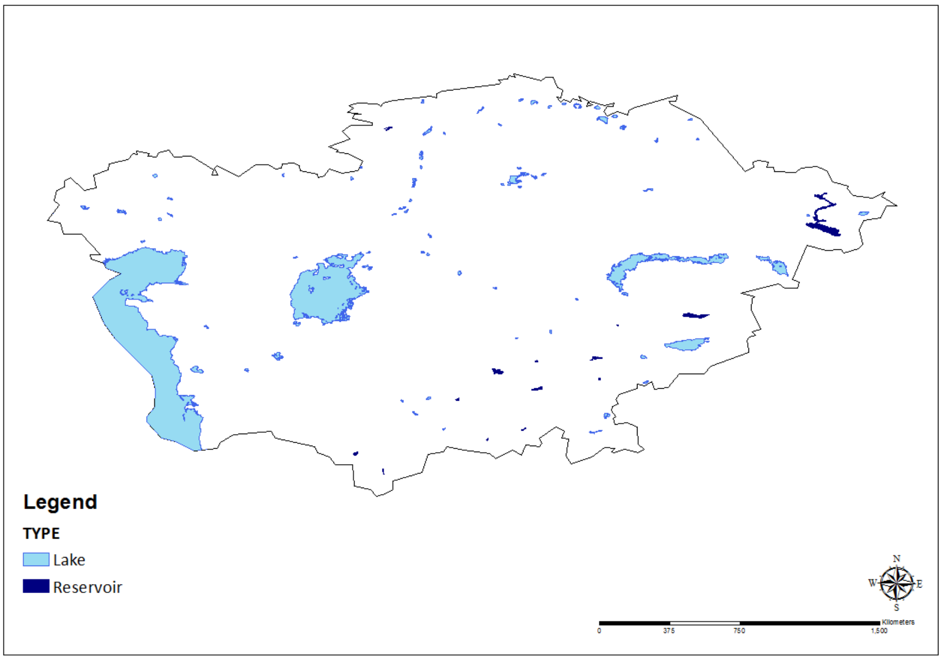
Water availability data

Different data were used to determine the availability of water sources (Table 1).

A. The global lakes and wetlands database (GLWD) is used to identify permanent water sources. This database has been developed and published since 2004 by Bernhard Lehner and Petra Döll in partnership with the Center for Environmental Systems Research (CESR), University of Kassel, Germany and the US office of the World Wildlife Fund (WWF-US). The database has been generated using and incorporating data derived from proprietary products of the Environmental Systems Research Institute, Inc. (ESRI), UNEP World Conservation Monitoring Centre (UNEPWCMC), and others.

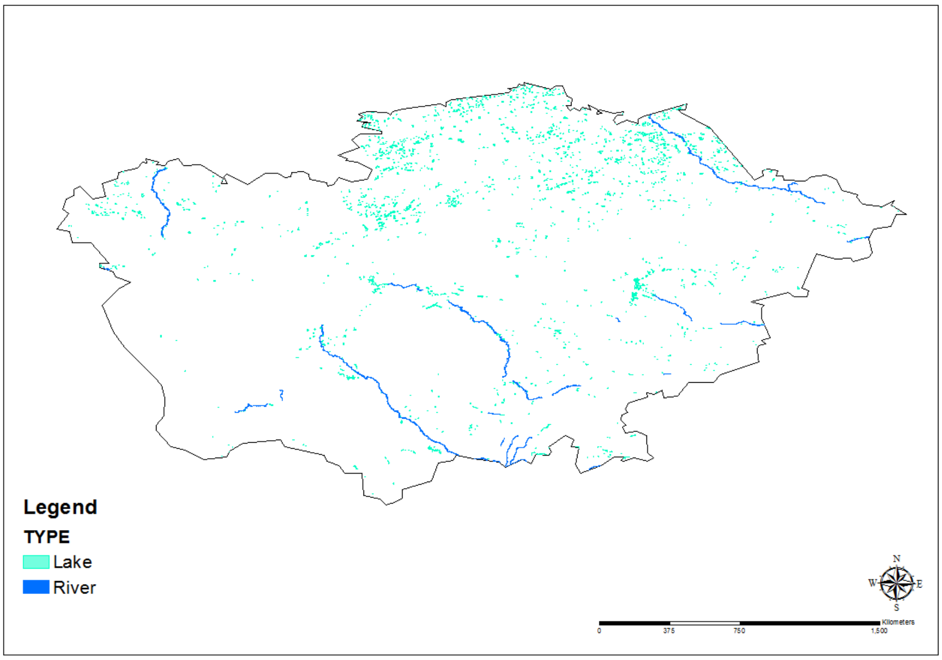
   The data combination of the best available sources for lakes and wetlands on a global scale (1:1 to 1:3 million resolution) and the application of GIS functionality, enabled the generation of a database which focuses on three coordinated levels:

   1. Level 1 (GLWD-1) comprises the shoreline polygons of the 3067 largest lakes (area = 50 km2) and 654 largest reservoirs (storage capacity = 0.5 km3) worldwide, and includes extensive attribute data. See (Map 28)



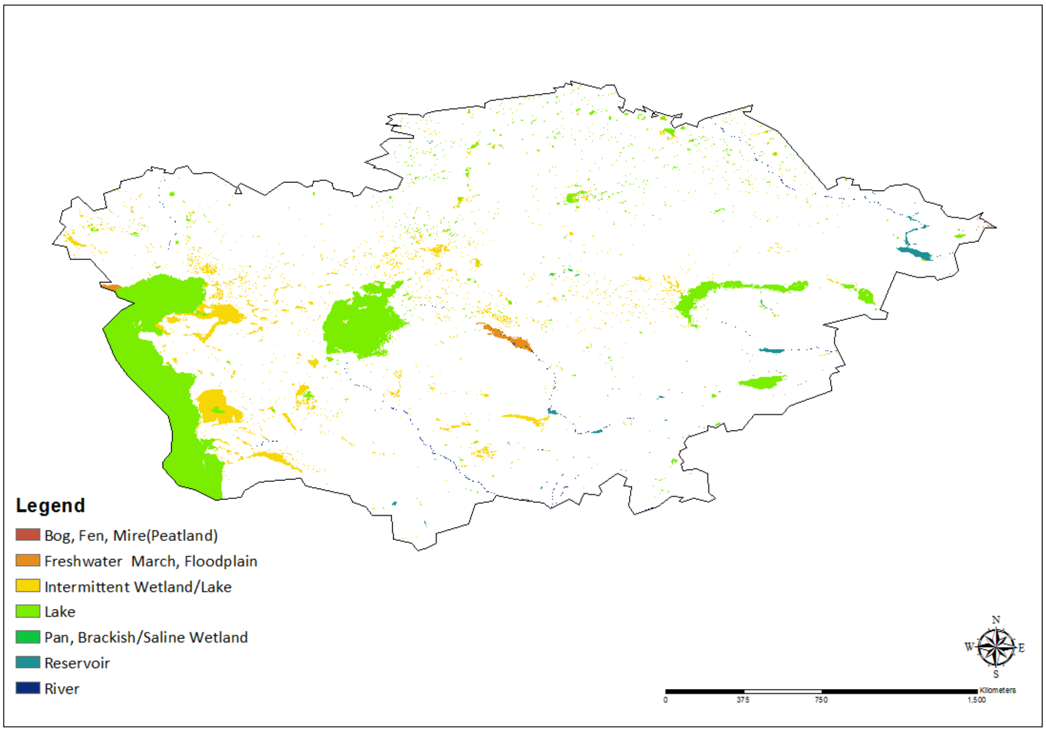
Map 28: The global lakes and wetlands database (GLWD) - Level 1

   2. Level 2 (GLWD-2) comprises the shoreline polygons of permanent open water bodies with a surface area greater than 0.1 km2 excluding the water bodies contained in GLWD-1. The approximately 250,000 polygons of GLWD-2 are attributed as lakes, reservoirs, and rivers. See (Map 29).



Map 29: The global lakes and wetlands database (GLWD) - Level 2

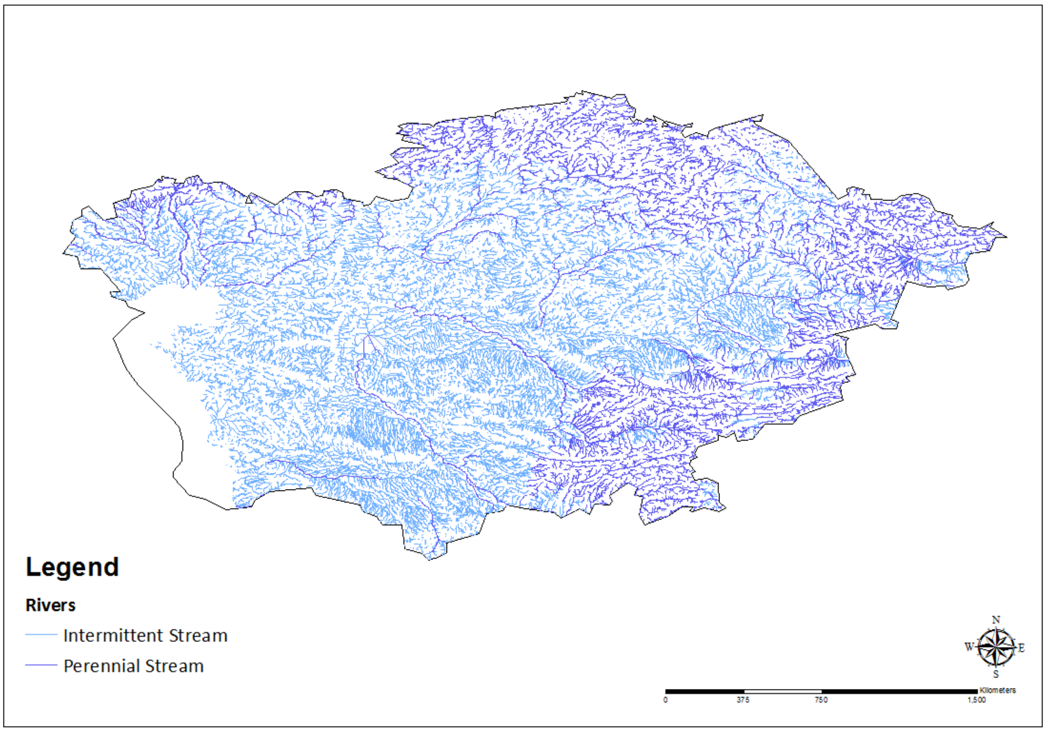
3. Level 3 (GLWD-3) comprises lakes, reservoirs, rivers, and different wetland types in the form of a global raster map at 30-second resolution. For GLWD-3, the polygons of GLWD-1 and GLWD-2 were combined with additional information on the maximum extents and types of wetlands. See (Map 30).



Map 30: The global lakes and wetlands database (GLWD) - Level 3

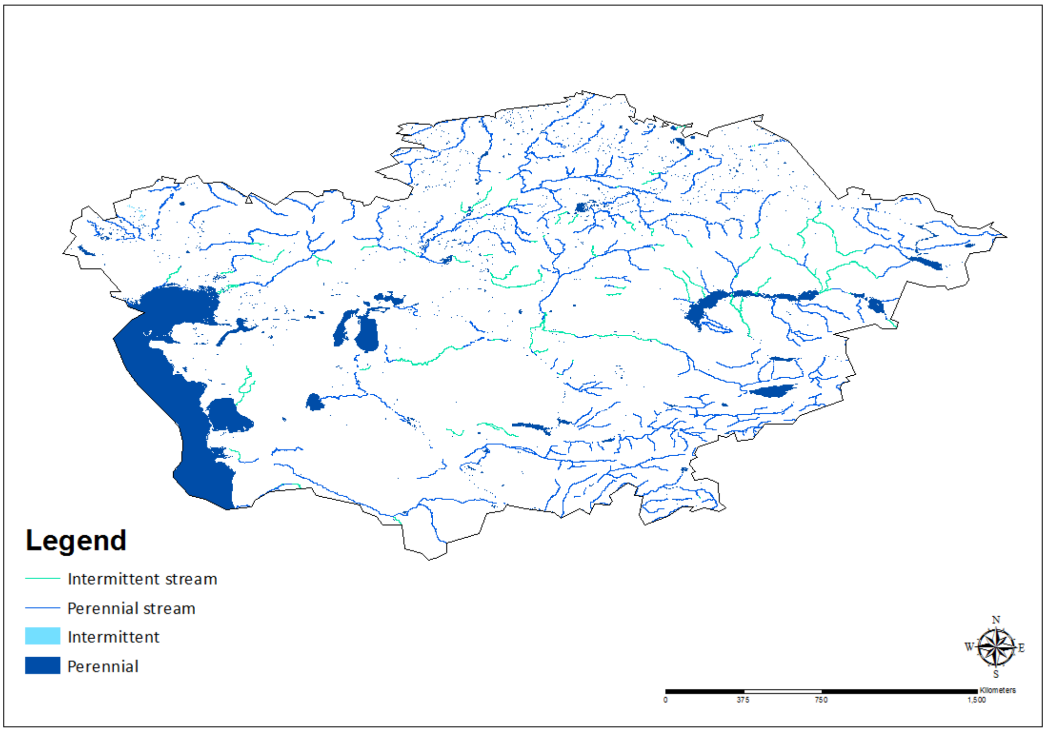
B. The FAO database provides information for rivers, which is derived from HydroSHEDS. The rivers of the Near East are derived from the World Wildlife Fund's (WWF) HydroSHEDS drainage direction layer and a stream network layer. The drainage direction layer was created from NASA's Shuttle Radar Topographic Mission (SRTM) 15-second Digital Elevation Model (DEM). The raster stream network was determined by using the HydroSHEDS flow accumulation grid, with a threshold of about 100 km^2 upstream area. The stream network dataset consists of the following information: the origin node of each arc in the network (FROM_NODE), the destination of each arc in the network (TO_NODE), the Strahler stream order of each arc in the network (STRAHLER), numerical code and name of the major basin that the arc falls within (MAJ_BAS and MAJ_NAME); - area of the major basin in square km that the arc falls within (MAJ_AREA); - numerical code and name of the sub-basin that the arc falls within (SUB_BAS and SUB_NAME); - area of the sub-basin in square km that the arc falls within (SUB_AREA); - numerical code of the sub-basin towards which the sub-basin flows that the arc falls within (TO_SUBBAS) (the codes -888 and -999 have been assigned respectively to internal sub-basins and to sub-basins draining into the sea). See (Map 31).

The attributes table now includes a field named "Regime" with tentative classification of perennial ("P") and intermittent ("I") streams.



Map 31: Rivers in Central Asia (Derived from HydroSHEDS) – FAO databases

C. World linear water and World water bodies are two layers available in the ArcGIS 10.1 package from ESRI. The World linear water (a line shapefile) provides all rivers and streams of the world and World water bodies (a polygon shapefile) provides the lakes, seas, oceans, and large rivers of the world. Both of the data sets classify the water lines and bodies into perennial and intermittent sources. See (Map 32).



Map 32: World linear water and world water bodies –ESRI database

Similarity analysis results – Part A

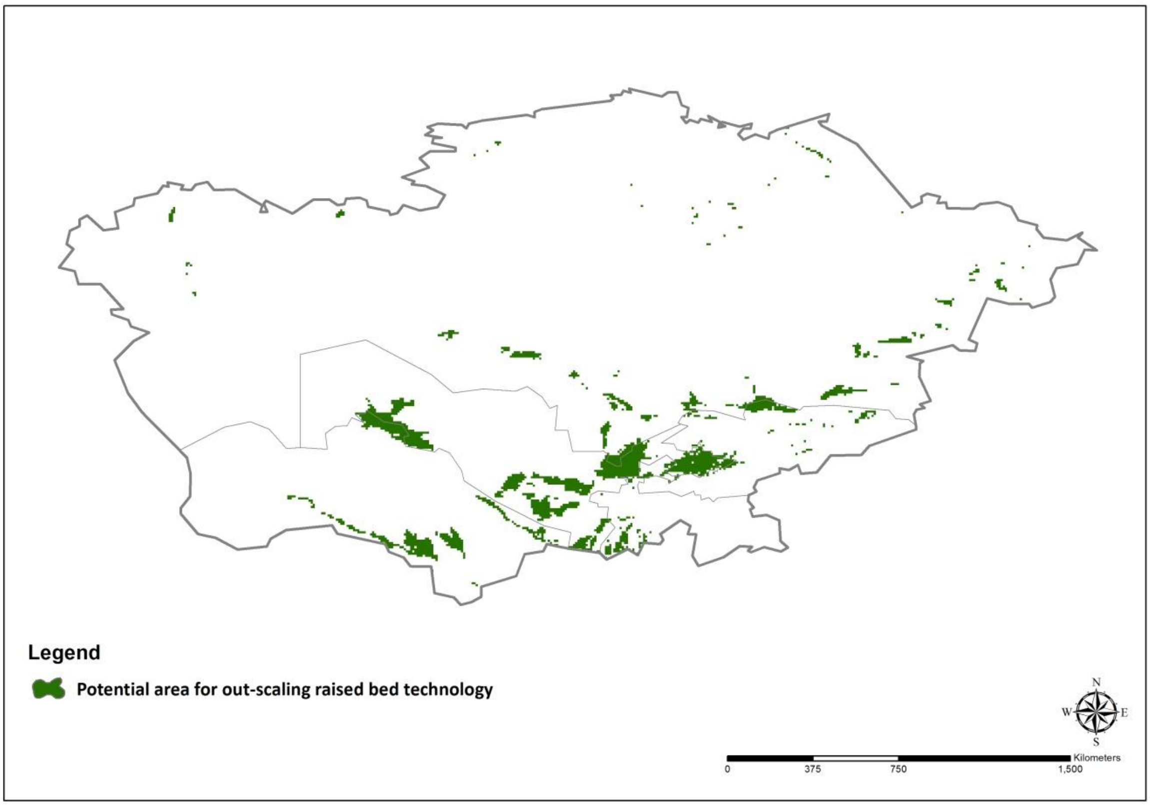
Potential areas for out-scaling raised-bed technology within the Irrigated agro-ecosystem

The following criteria were used to map the potential areas for out-scaling raised-bed technology within the irrigated agro-ecosystem. The source of each criterion is indicated in Table 10.

Table 10: Data sources for the defining the potential areas for out-scaling raised-bed technology within the Irrigated agro-ecosystem

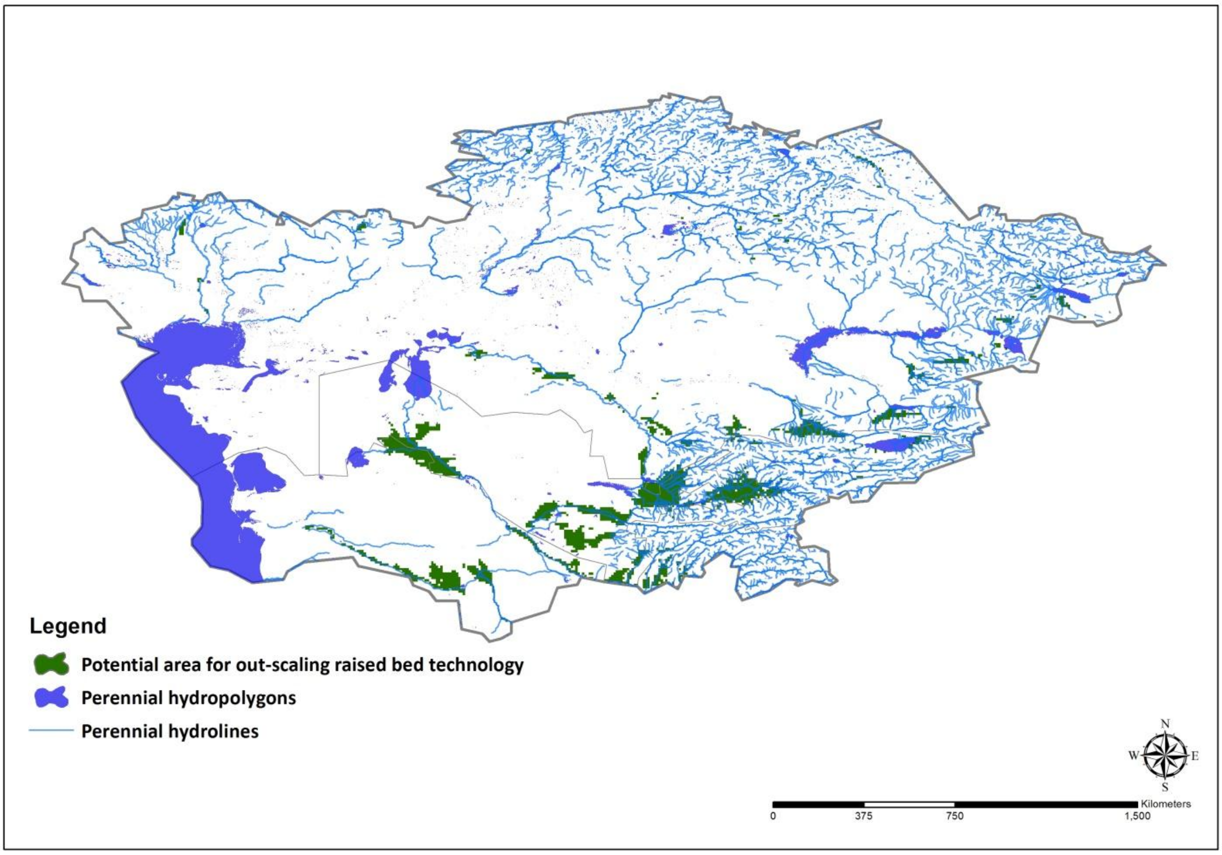
Irrigated agro-ecosystem	Similarity criteria	Refer to
Land use	Irrigated land	Map 10
Slope, degree	0-5	Map 2
Water availability/source	Sufficient	Maps (28-32) shows the distribution of water resources in Central Asian countries
Soil (texture), clay content, %	10-75 physical clay	Map 21
Soil salinity, %	Non saline soil: Electrical Conductiviy < 8	Map 27

By overlaying the land use, slope degree, soil texture, and soil salinity layers, the potential areas for out-scaling raised bed technology in Central Asia was produced Map 33.



Map 33: Potential area for out-scaling raised bed technology within the irrigated areas.

Important note: *Irrigated agro-ecosystem criteria included the availability of water sources; the result of the similarity analysis shows the irrigated areas close to the perennial water source. Map 34.*



Map 34: Potential area for out-scaling raised bed technology and the proximity to perennial water sources

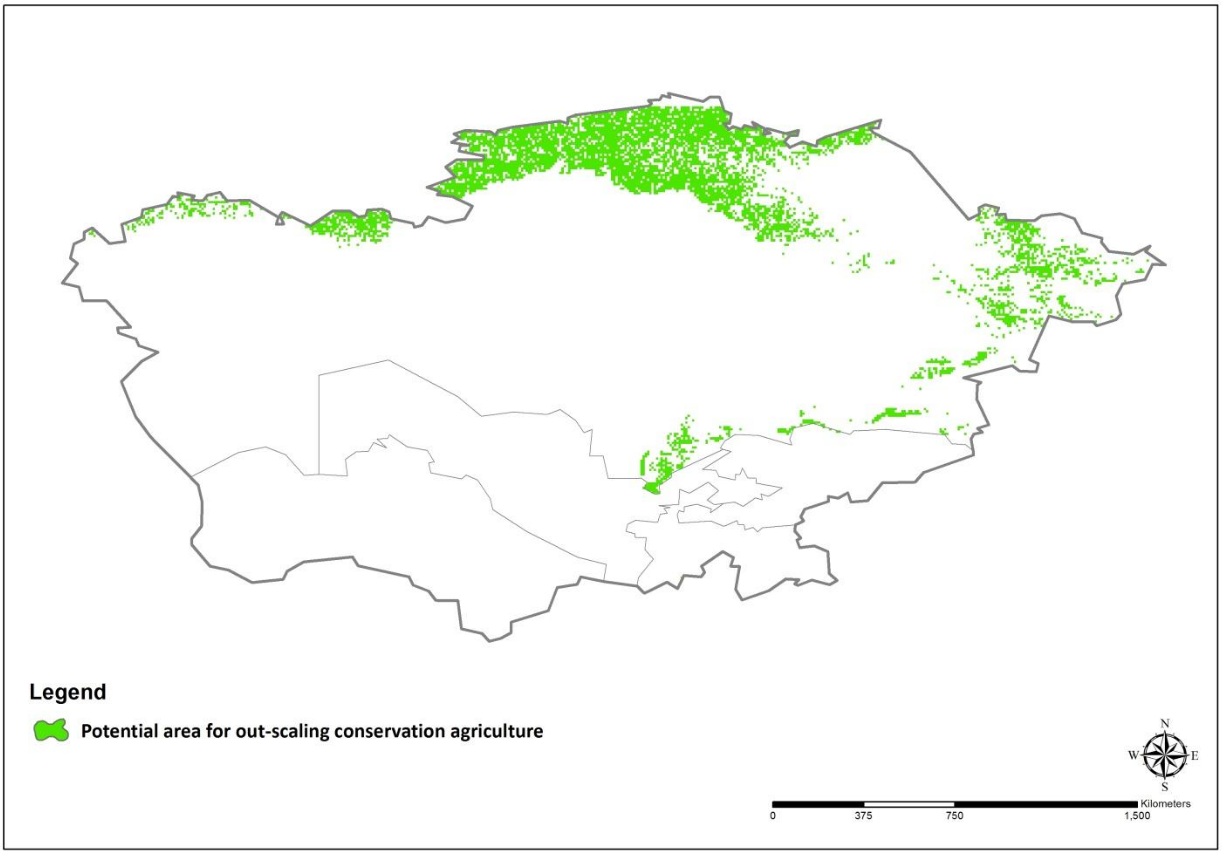
Potential areas for out-scaling conservation agriculture within the rainfed agro-ecosystem

The following criteria were used to map the potential areas for out-scaling conservation agriculture within the rainfed agro-ecosystem. The source of each criterion is indicated in the Table 11.

Table 11: Data sources for the defining the potential areas for out-scaling conservation agriculture within the rainfed agro-ecosystem

Rainfed agro-ecosystem	Similarity criteria	Refer to
Precipitation	300-600	Map 19
Slope, degree	<7	Map 3
Land use	Cropland	Map 12
Soil (texture), clay content, %	20-75 physical clay	Map 22

By overlaying the above prepared layers the potential areas for out-scaling conservation agriculture within the rainfed agro-ecosystem in Central Asia were generated Map 35.



Map 35: Potential area for out-scaling conservation agriculture within the rainfed agroecosystem.

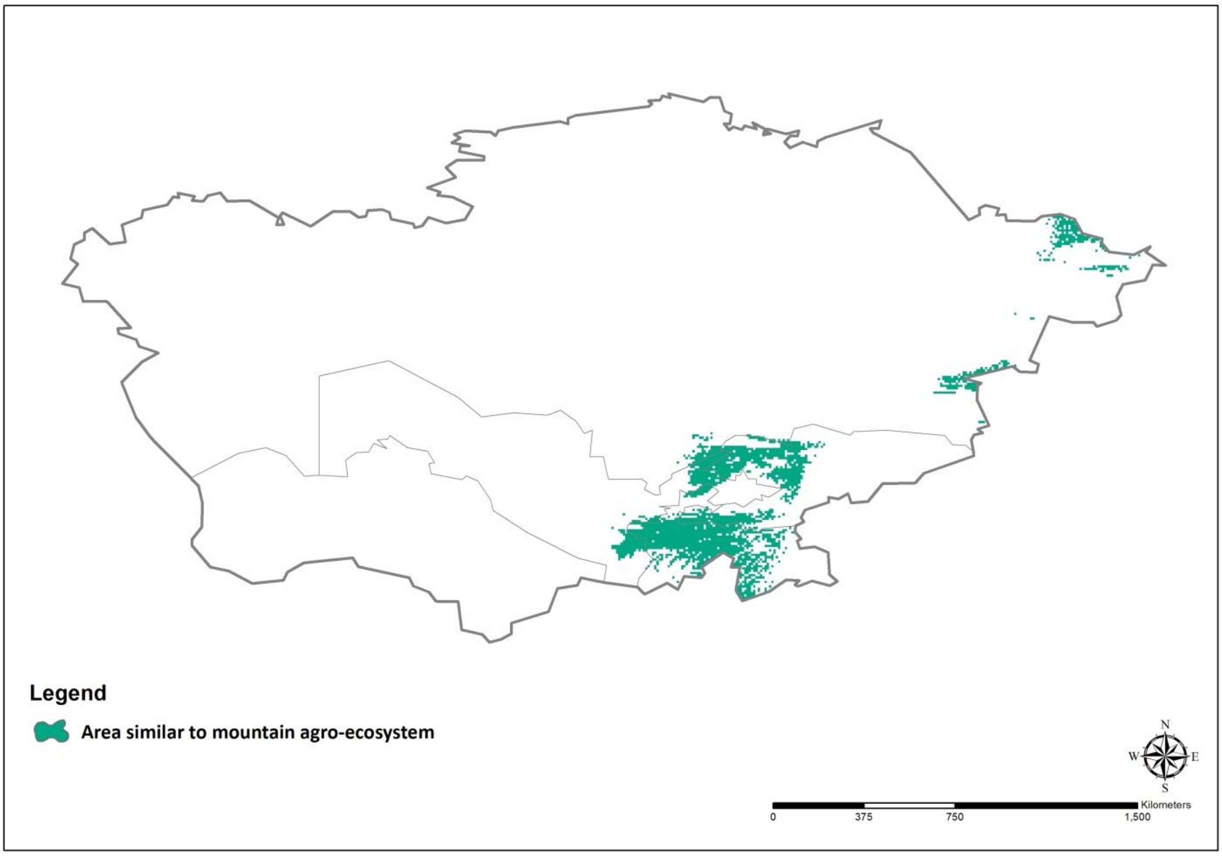
Potential areas for out-scaling agro-forestry technologies within the mountain agro-ecosystem

The following criteria were used to map the potential areas for out-scaling agro-forestry technologies within the mountain agro-ecosystem. The source of each criterion is indicated in Table 12.

Table 12: Data sources for the defining the potential areas for out-scaling agro-forestry technologies within the mountain agro-ecosystem

Mountain agro-ecosystem	Similarity criteria	Refer to
Slope, degree	>7	Map 4
Precipitation	>500	Map 20
Altitude, m	>800	Map 6
Land use	exclude inconvinient areas (rocks, gullies etc.)	Map 13
Soil depth, cm	>50	Map 24

By overlaying the above prepared layers the potential areas for out-scaling agro-forestry technologies within the mountain agro-ecosystem in Central Asia were generated Map 36.



Map 36: Potential area for out-scaling mountain agro-forestry

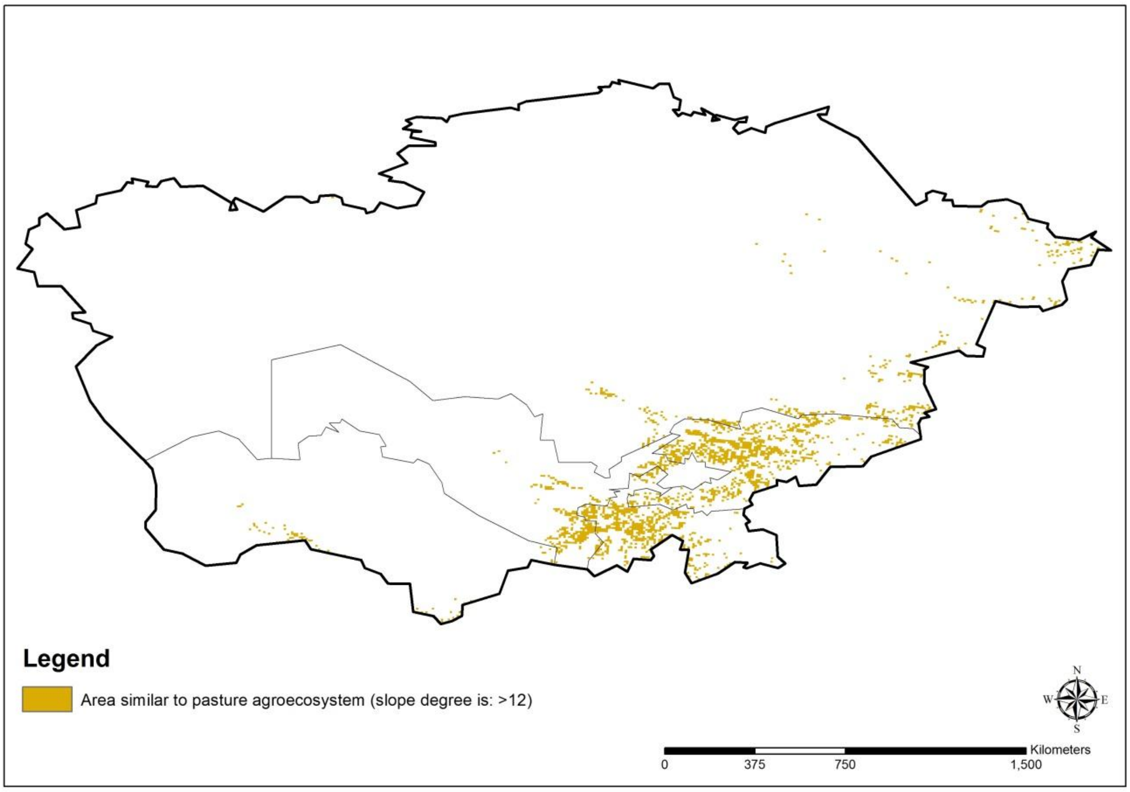
Potential areas for out-scaling pasture improvement technologies within the rangelands agro-ecosystem

The following criteria were used to map the potential areas for out-scaling pasture improvement technologies within the areas similar to the rangeland agro-ecosystem. The source of each criterion is indicated in Table 13.

Table 13: Data sources for the defining the potential areas for out-scaling pasture improvement technologies within the rangelands agro-ecosystem

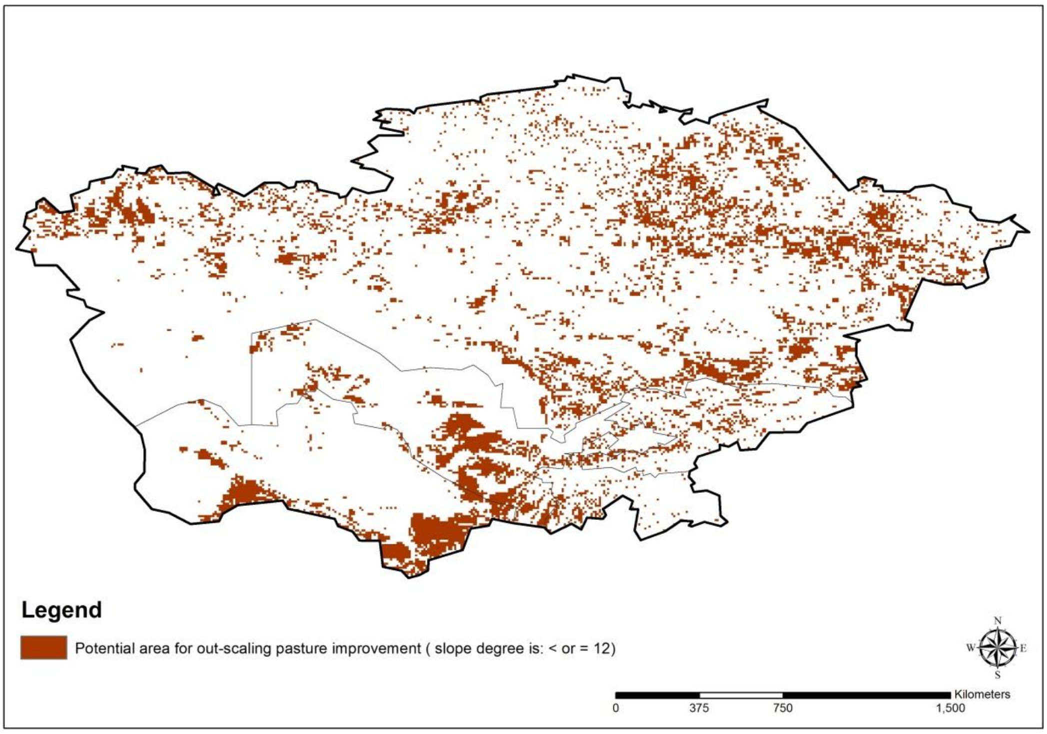
Rangelands agro-ecosystem	Similarity criteria	Refer to
Land use	rangelands, pasture	Map 15
Slope, degree	>12	Map 5
Precipitation	this will be discussed during the workshop	
Degradation degree	Areas with weak, medium to strong degradation as well as the Bareland areas	Map 8
Livestock density per ha	Areas with high and moderate livestock density	Map 17
Watering points/ha	data not available	

By overlaying the above prepared layer the potential areas for out-scaling pasture improvement in Central Asia were generated Map 37.

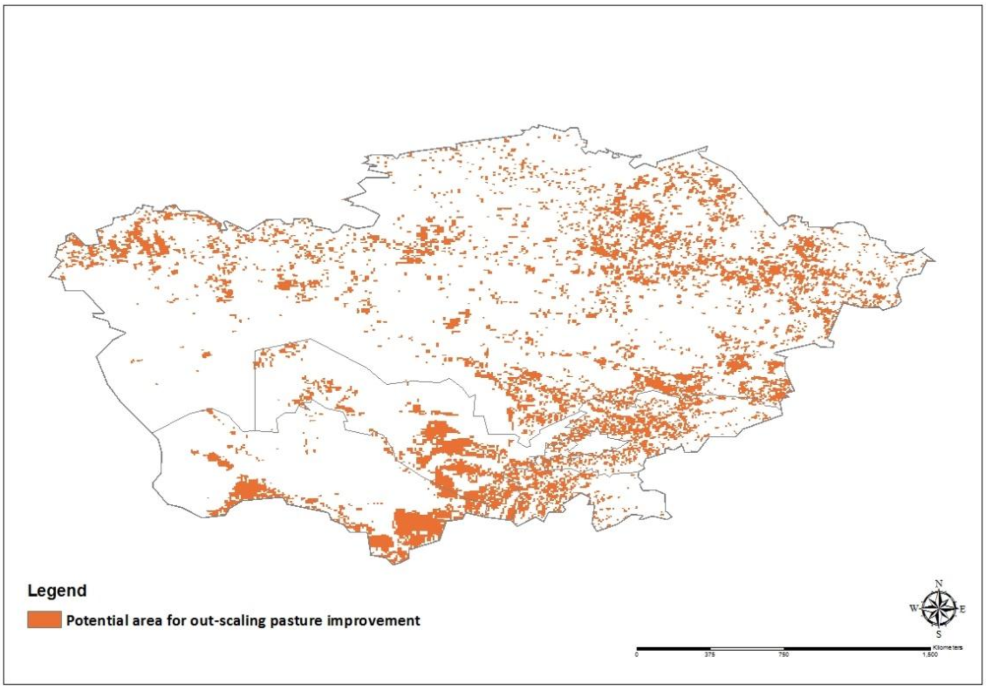


Map 37: Potential area for out-scaling pasture improvement within the rangeland agro-ecosystem (slope degree > 12)

In reviewing this map the result of the analysis shows that most of the rangelands are in the mountain area, whereas rangelands are dominant also in flat areas. This was because the slope criterion considered only slope above 12 degrees. Therefore the analysis was repeated to include areas with slope less than or equal to 12 degrees (Map 38).

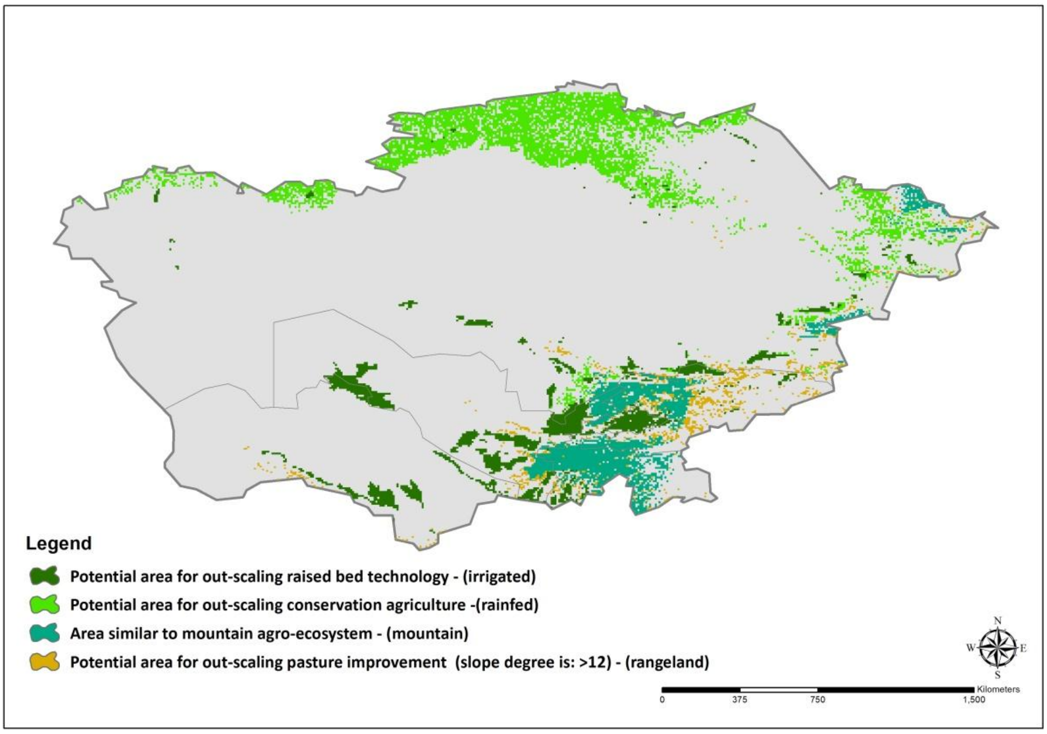


Map 38: Potential area for out-scaling pasture improvement with slope degree < or = 12.

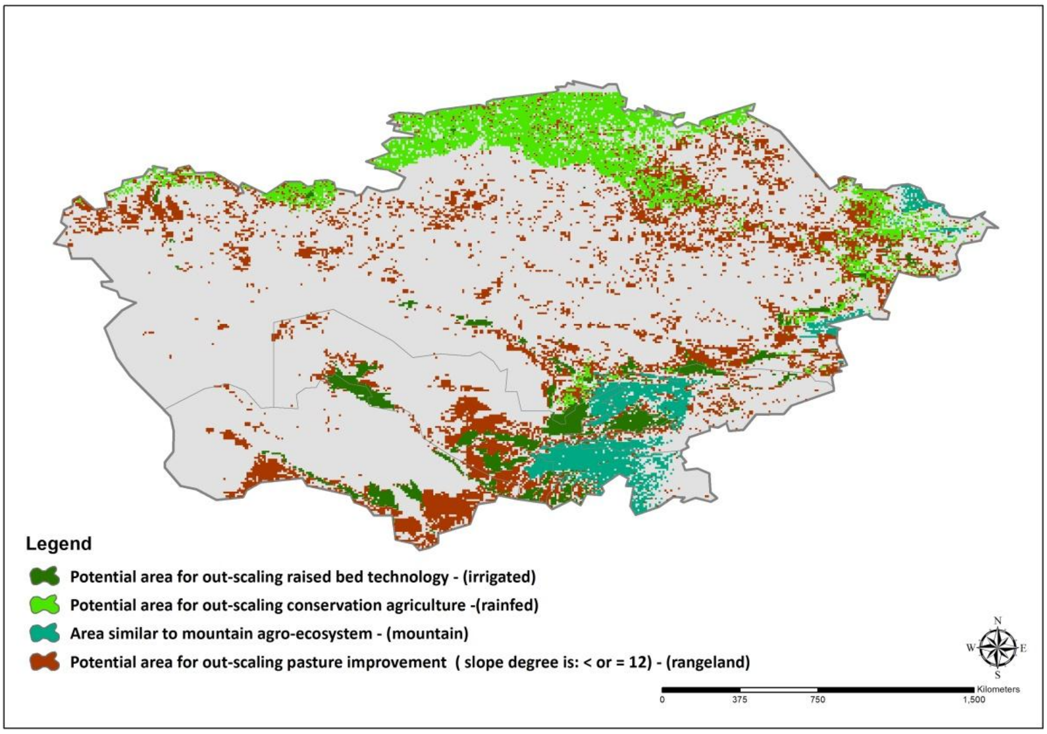


Map 39: Potential area for out-scaling pasture improvement (all slope classes)

The maps below show the combined results of the similarity analysis for the four agro-ecosystems:



Map 40: Simialr areas for the four agro-ecosystem (areas with slope more than 12 degree for rangeland)



Map 41: Simialr areas for the four agro-ecosystem (areas with slope less than or equal 12 degree for rangeland)

Similarity analysis results – Part B

Verification of the similarity maps based on national experts' participation and country level data

The similarity analysis results in the above section were presented and discussed with local experts from the participating countries. Appendix 4 includes the details about the fine-tuning workshop. During the fine-tuning workshop each map was presented and enough time was allocated for each agro-ecosystem similarity analysis results and after consulting the participants the criteria were modified as in Table 14.

Table 14: Modified similarity criteria for selected SLM technologies in each target agro-ecosystem

Irrigated agro-ecosystem / Potential area for out-scaling raised bed technology	Similarity criteria Original	Modification
Land use	Irrigated land	***The data used in the first analysis is merged with data received on national level***
Slope, degree	0-5	
Water availability/source	Sufficient water resources	
Soil (texture), clay content, %	10-75 physical clay	
Soil salinity, %	< 8 dS m^{-1}	***Exclude the high and very high values, this already presented in the previous similarity analysis. See Table 9***

Rainfed agro-ecosystem / Potential area for out-scaling conservation agriculture	Similarity criteria	Modification
Precipitation	300-600	
Slope, degree	<7	
Land use	Cropland	***The data used in the first analysis present the cropland in the rainfed areas this layer should be merged with the data received on natioanl level***
Soil (texture), clay content, %	20-75 physical clay	

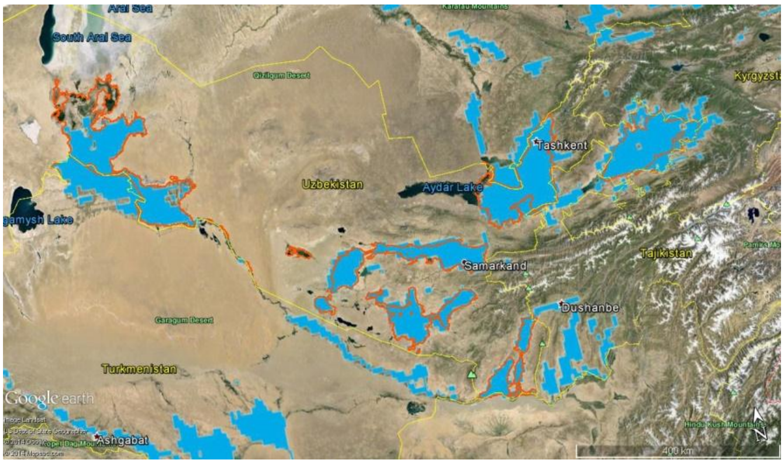
Mountain agro-ecosystem / Potential area for out-scaling mountain agro-forestry	Similarity criteria	Modification
Slope, degree	>7	
Precipitation	>500	
Altitude, m	>800	***800 – 3000 beyond 3000m the national experts indicated limited agricultural activies***
Land use	exclude inconvinient areas (rocks, gullies etc.)	
Soil depth, cm	>50	

Rangelands agro-ecosystem / Potential area for out-scaling pasture improvement	Similarity criteria	Modification
Land use	rangelands, pasture	
Slope, degree	>12	***Not to be considered because rangeland are distributed over large range of slope***
Precipitation	this was not considered	***Not to be considered***
Degradation degree	Areas with weak, medium to strong degradation as well as the Bareland areas	***Agreed on what had been choosen***
Livestock density per ha	Areas with high and moderate livestock density	***Agreed on what had been choosen***
Watering points/ha	Data not available	***Not to be considered because the degradation degree and livestock are good indicators of rangeland degradation***

During the workshop the participants from Uzbekistan and Kazakhstan provided irrigated and rainfed shape files and from Kyrgyzstan the rainfed layer.

These layers were put over the results of the potential area for out-scaling raised bed technology (irrigated) and conservation agriculture (rainfed) on Google Earth professional software for discussion. This comparison highlighted the following issues:

1. Irrigated layer received from Uzbekistan, adopted at national level, are mostly located within the large scale irrigated areas used for the first round of the similarity analysis See (Map 42). This confirms that the data used for the similarity analysis is reflecting the situation on the ground and could provide additional information to what is available at national level.
2. The results of the similarity analysis for out-scaling the raised bed technology (irrigated) were more accurate from the layers received from Kazakhstan. Since some of the water bodies were included in the layer as irrigated areas as well as the urban areas (Map 43).



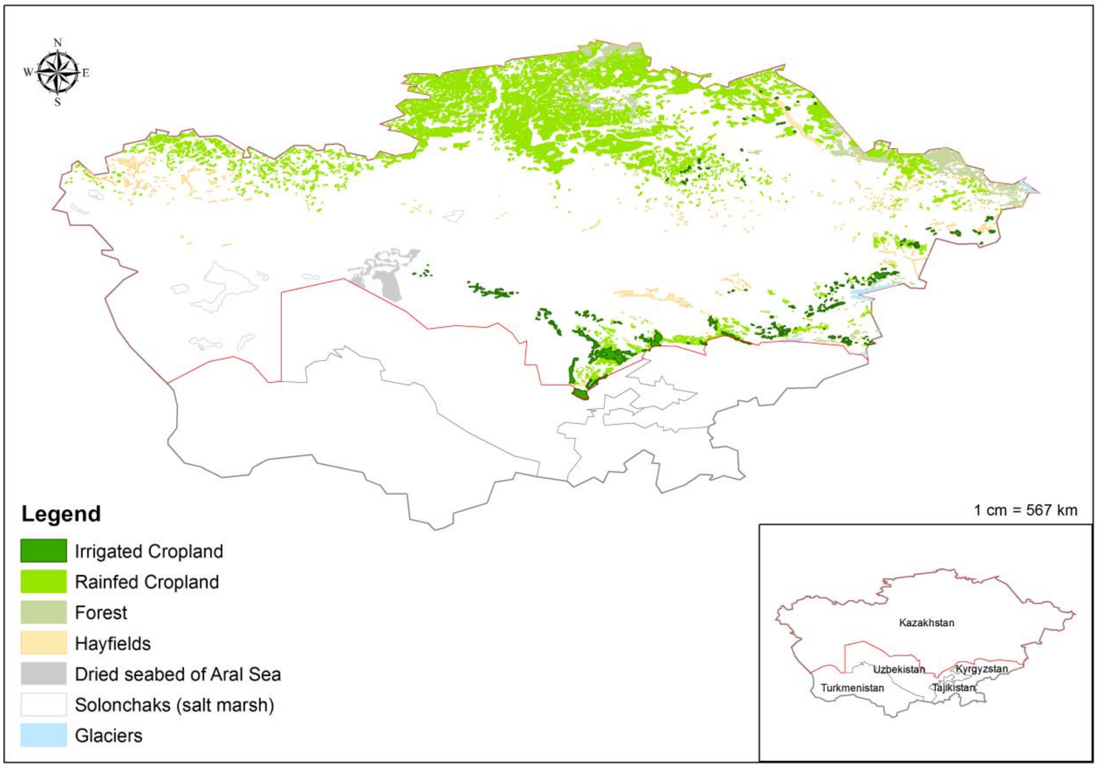
Map 42: Large scale irrigation areas (used from LADA project) and irrigated areas layer received from Uzbekistan

Map 43: Irrigated layer shows some water bodies and population

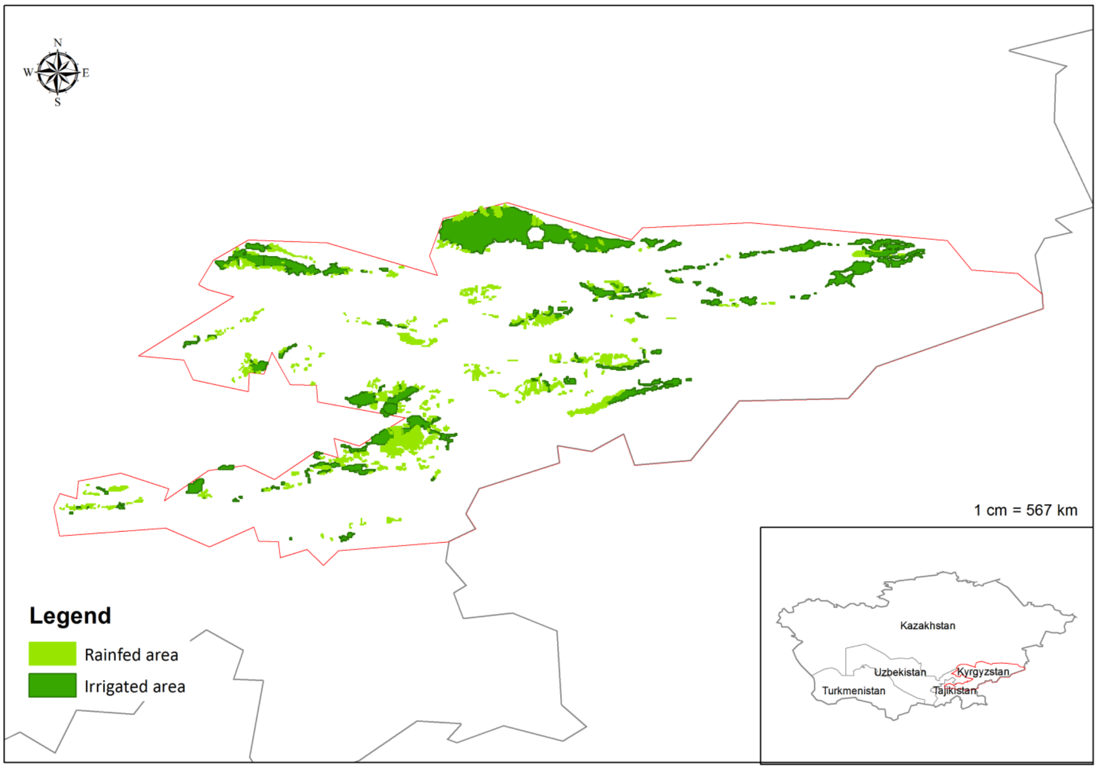
According to the discussion with the national experts and understanding the need for similarity analysis, the participants provided the rainfed and irrigated areas available from different sources within their countries to support the similarity analysis at regional level (Table 15). The received data (Maps 44-48) were checked for consistence and were used as input to revise and fine-tune the similarity maps.

Table 15: National data used for fine-tuning similarity maps

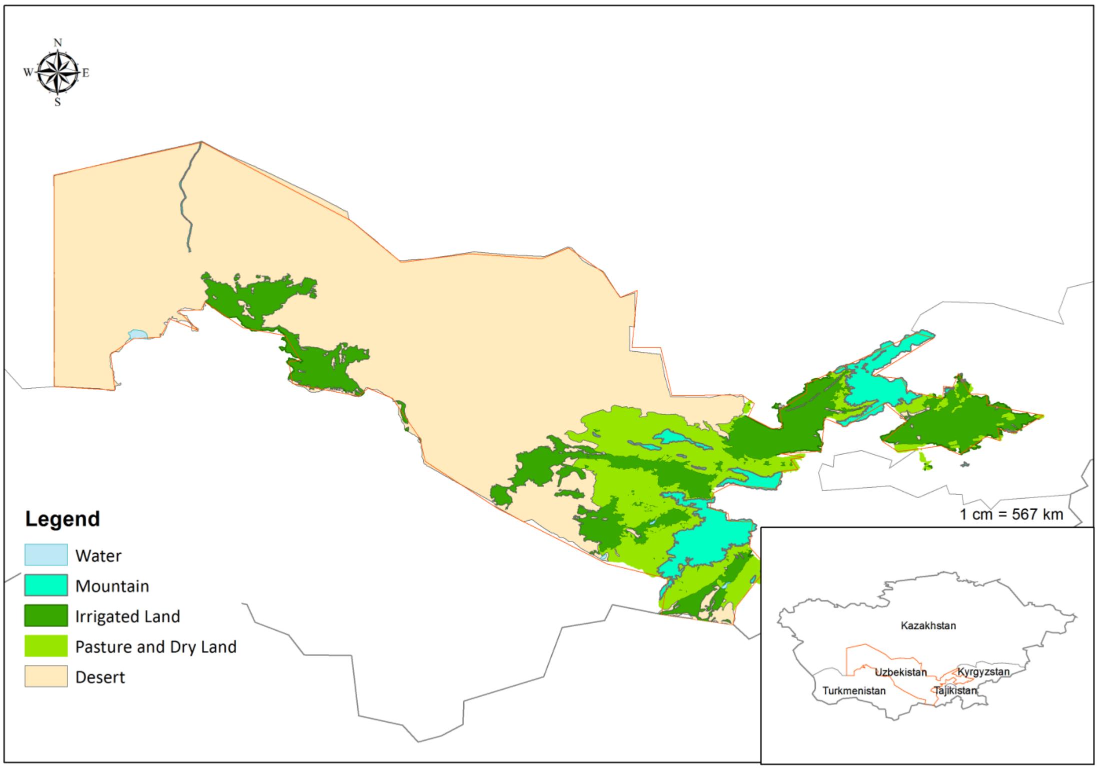
Country	Data source/s
Uzbekistan	- Soil Map of the Republic of Uzbekistan, produced by GOSCOMZEMGEODESCADASTRE in **2008** - ATLAS of Soil Cover of the Republic of Uzbekistan, printed by GOSCOMZEMGEODESCADASTRE in **2010**
Kazakhstan	- Socio-Economic Atlas of Republic of Kazakhstan, Vol.2, Land use Map, produced by Institute of Geography in **2010**
Kyrgyzstan	- Land use map of Kyrgyz Republic. The report Ms. Kelgenbaeva Kamila "The results of IP-SLM, CACILM Phase I (Information system component, **2008-2010**).
Tajikistan	- Atlas of the Tajik SSR, Soil and Land use Map, produced by the department of Geodesy and Cartography under the Council of Ministers of the USSR in **1968**



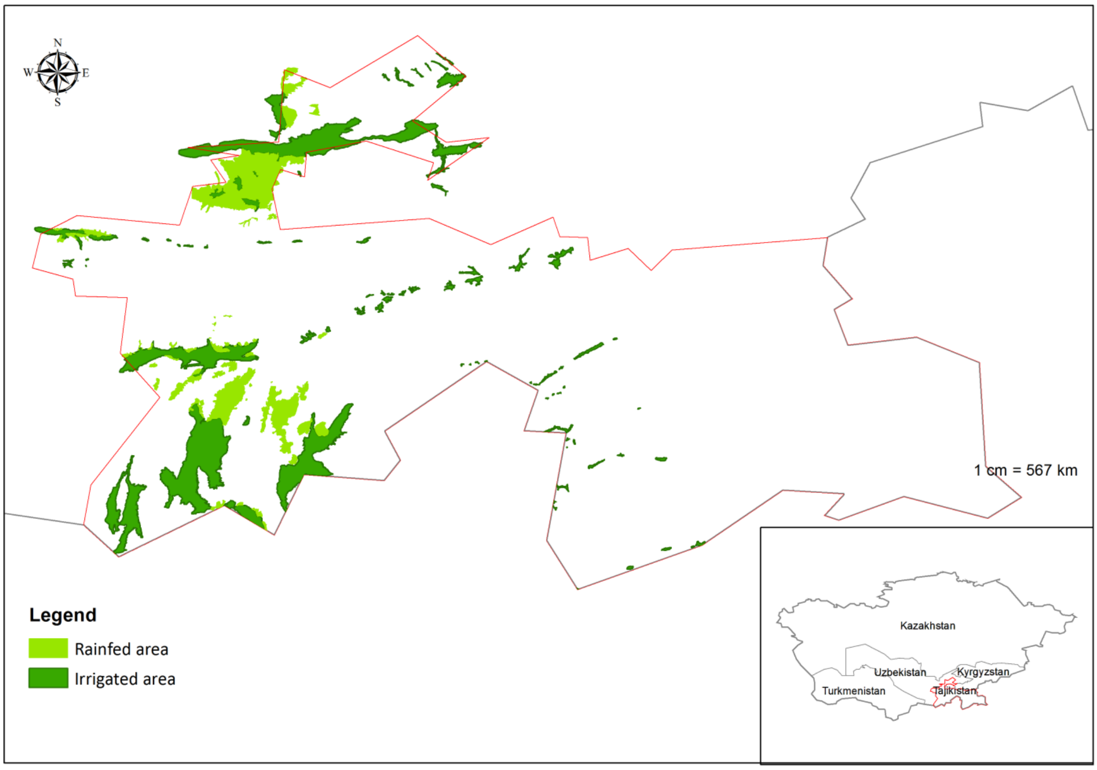
Map 44: Land use layers received from Kazakhstan



Map 45: Land use layers received from Kyrgyzstan

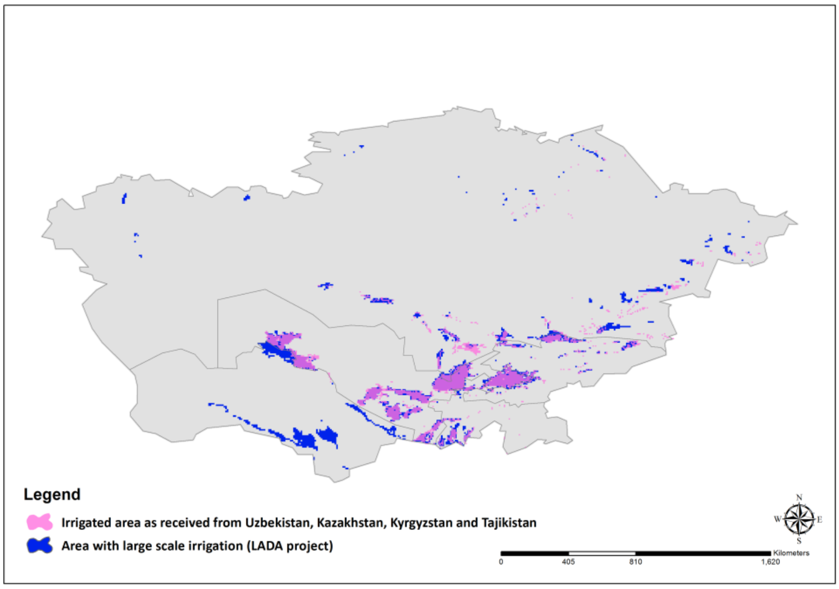


Map 46: Land use layers received from Uzbekistan

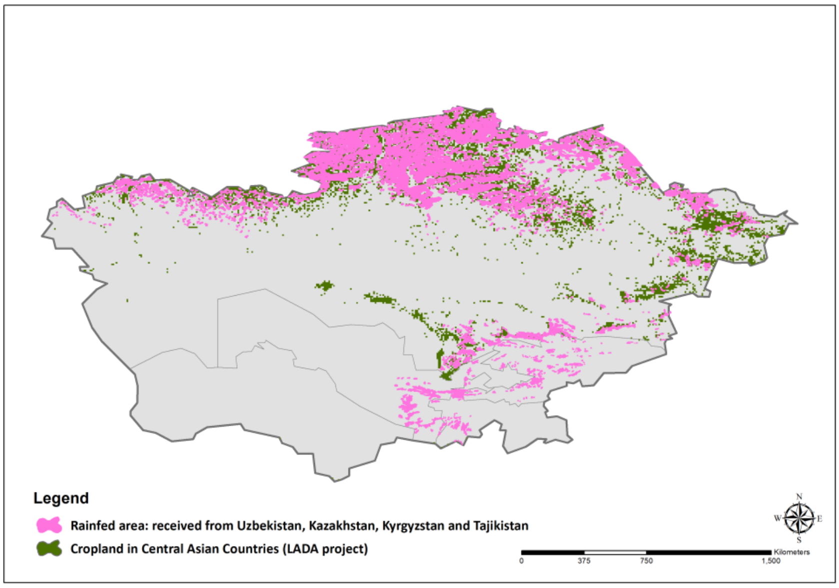


Map 47: Land use layers received from Tajikistan

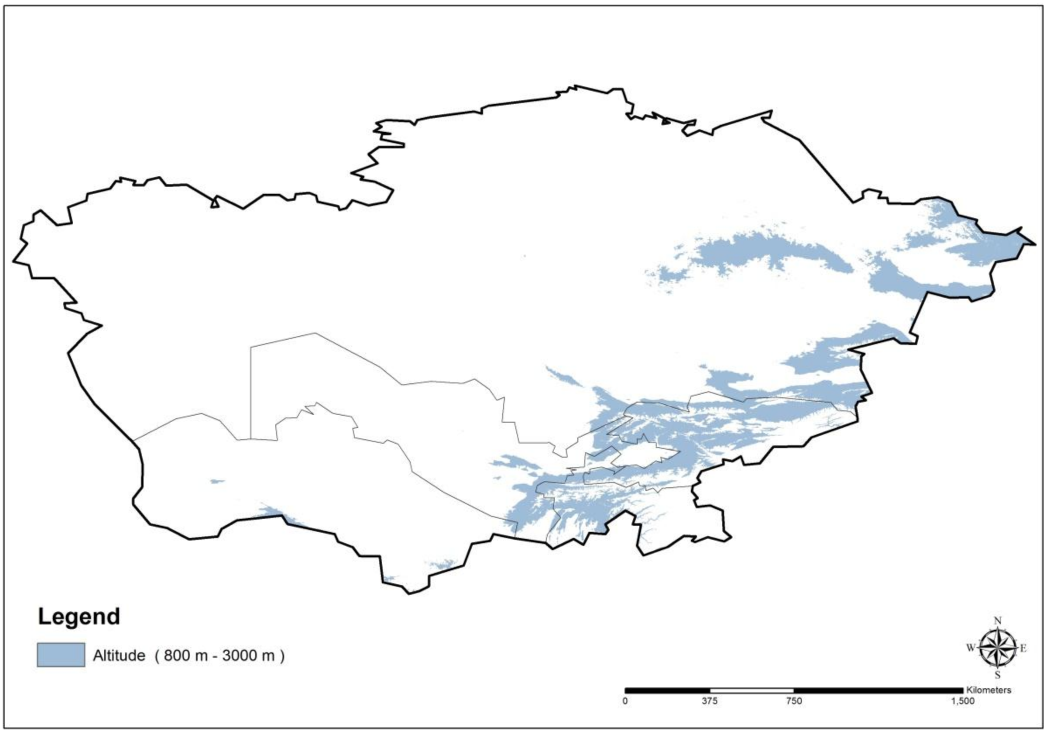
By merging the new set of data received from countries with the original land use data, an updated land use maps for the irrigated and rainfed agro-ecosystems were generated. (Map 48 and Map 49) show the new land use layer that was considered for the analysis for the potential area for out-scaling raised bed technology in the irrigated areas and the conservation agriculture in the rainfed areas. (Map 50) shows the areas with 800- 3000 altitude.



Map 48: New land use layer for the irrigated agro-ecosystem



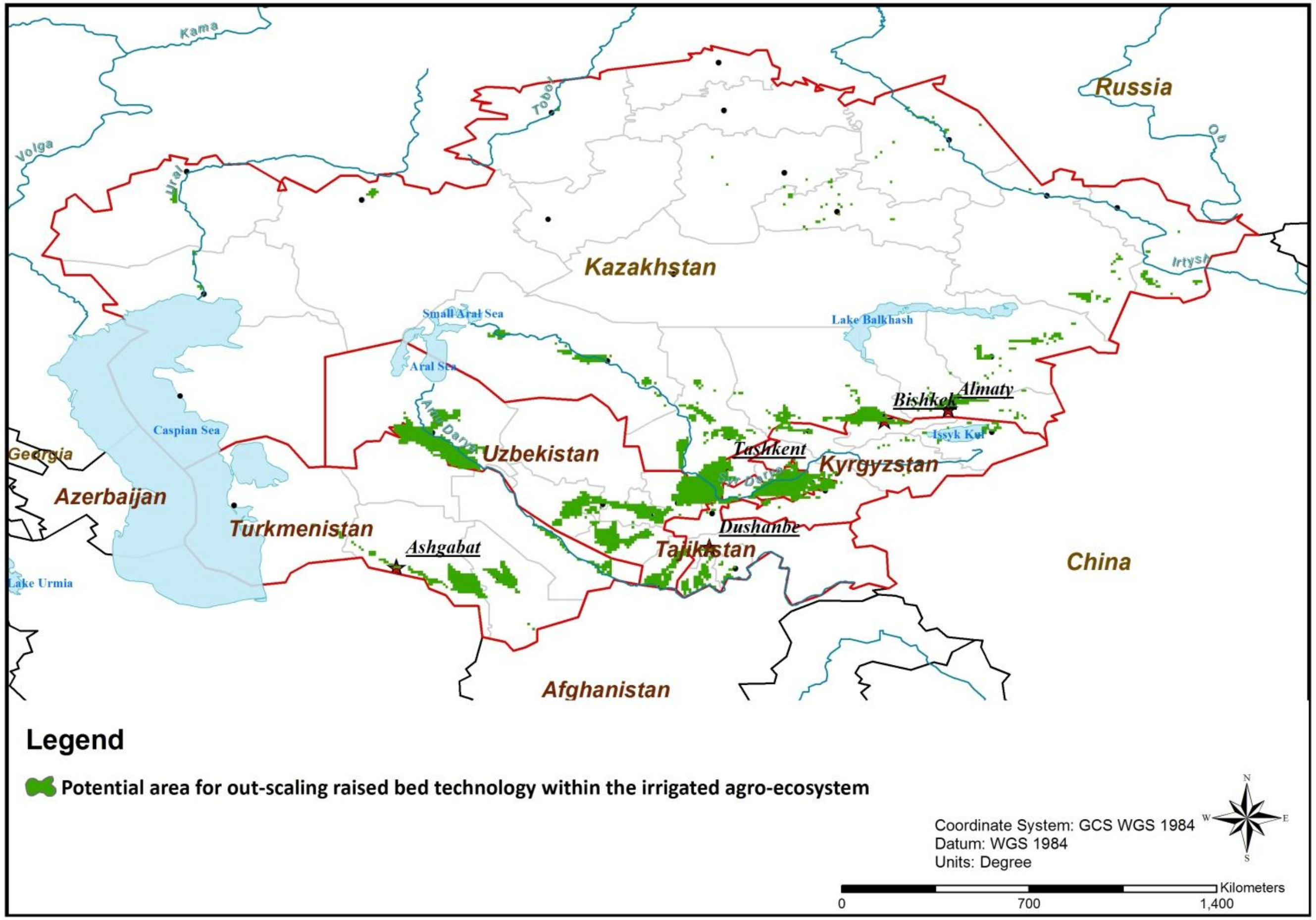
Map 49: New land use layer for the rainfed agro-ecosystem



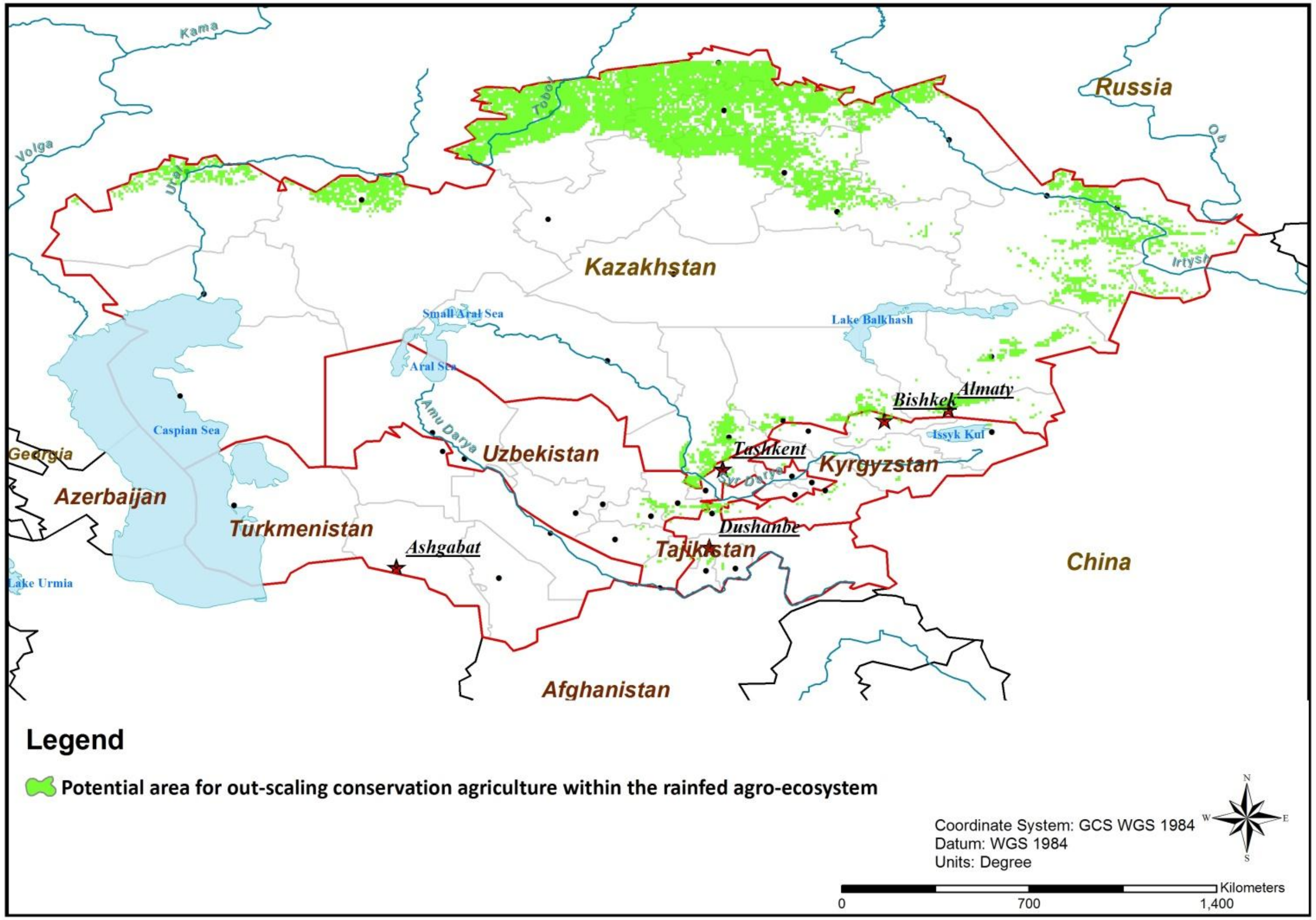
Map 50: Areas with altitude 800 – 3000 m

Similarity Maps of Central Asian Countries

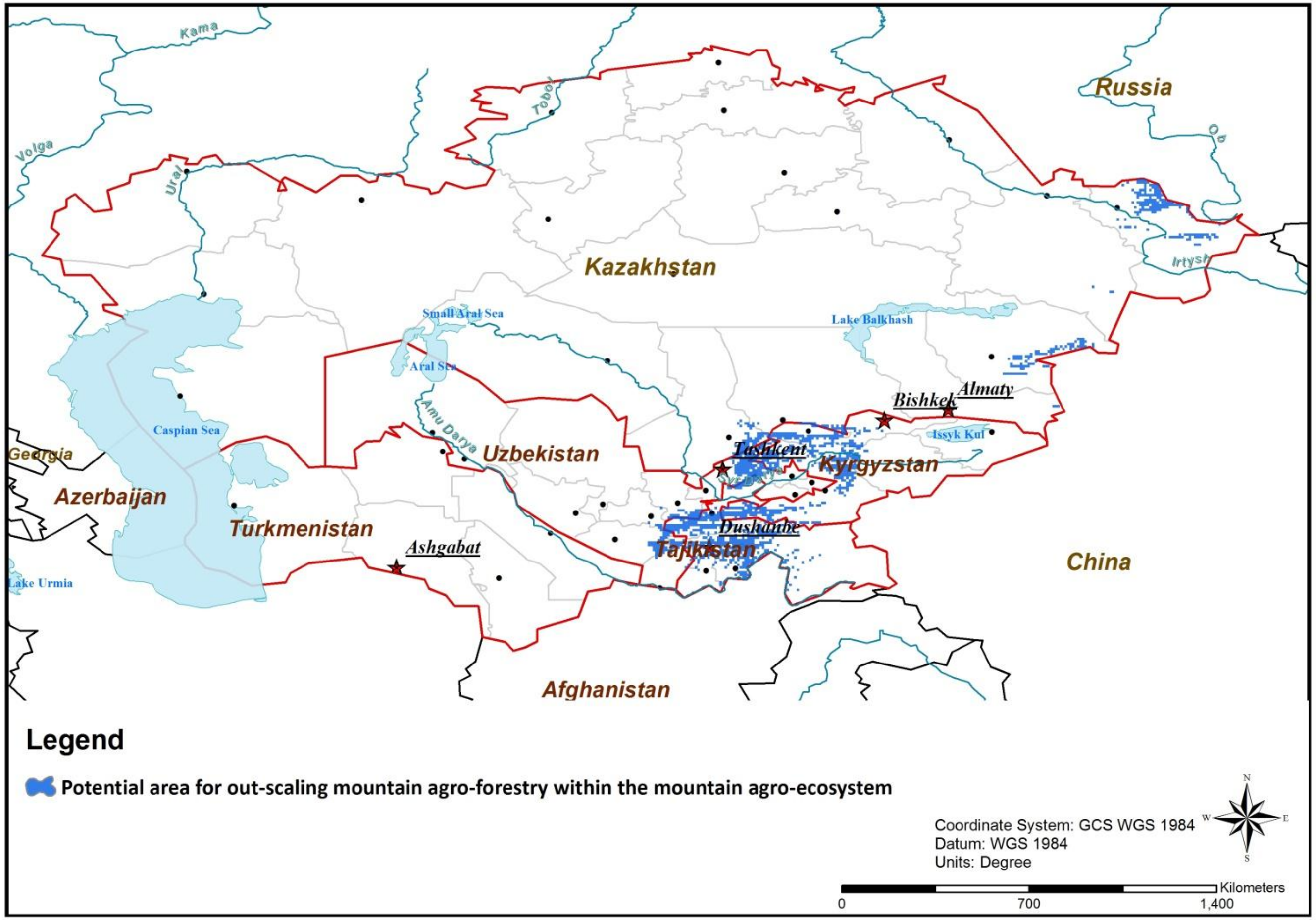
Taking into consideration the suggested modifications to the similarity criteria by the national experts and using the updated maps based on national data received from the participating countries, a new set of similarity maps were generated (Maps 51-54) for each agro-ecosystem and Map 55 for the four agro-ecosystems.



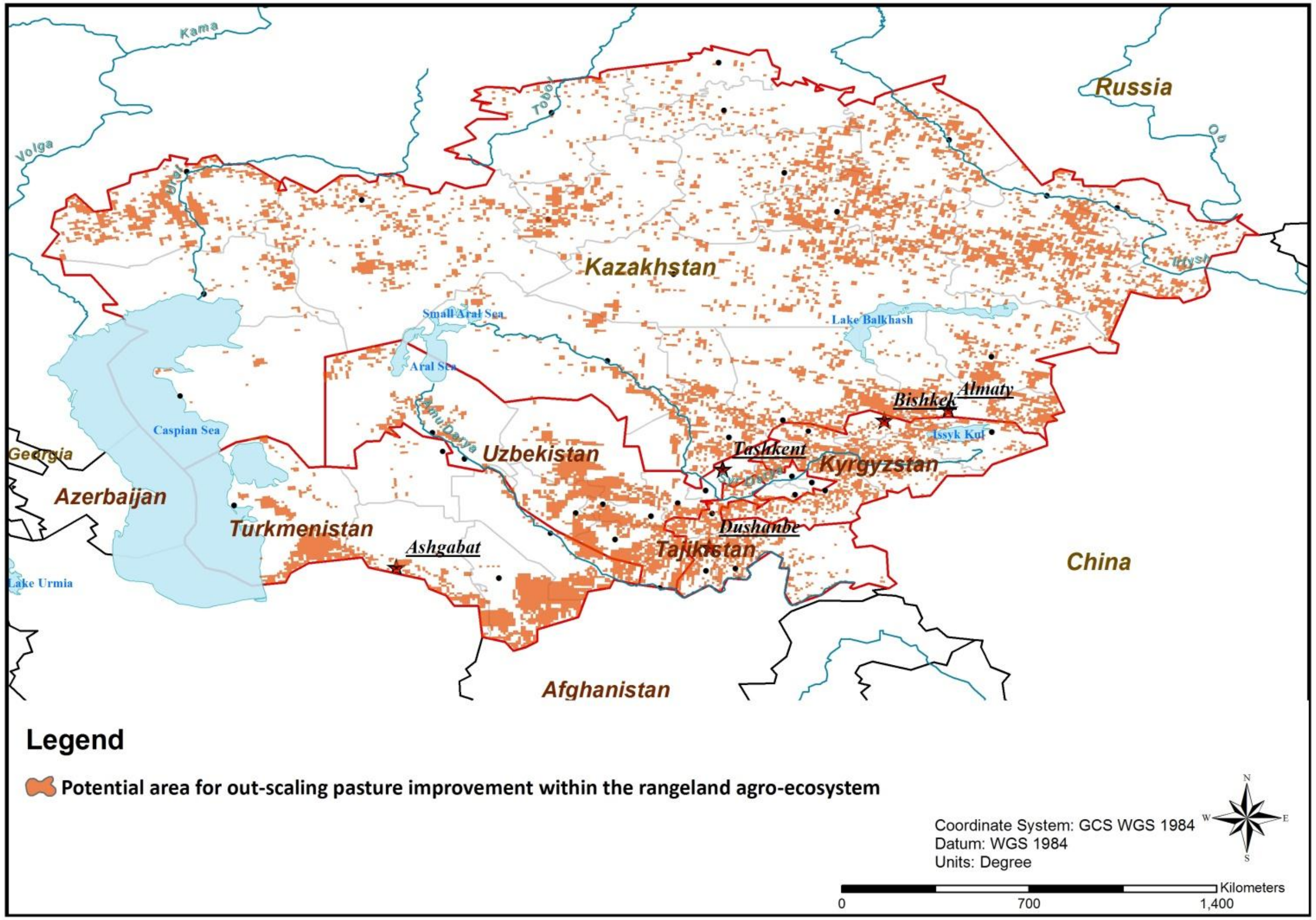
Map 51: Potential area for out-scaling raised bed technology within the irrigated agro-ecosystem



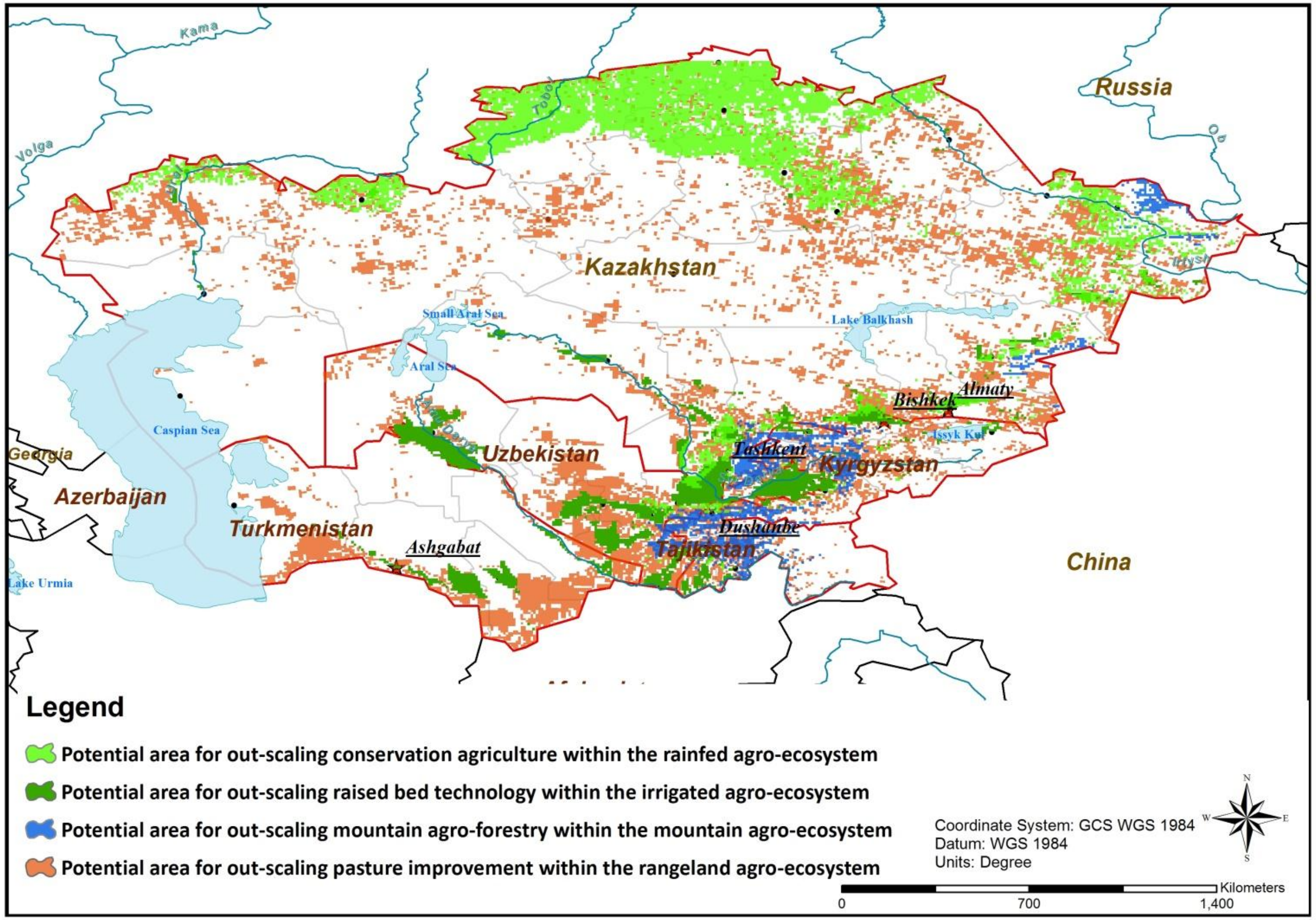
Map 52: Potential area for out-scaling conservation agriculture within the rainfed agro-ecosystem



Map 53: Potential area for out-scaling mountain agro-forestry within the mountain agro-ecosystem



Map 54: Potential area for out-scaling pasture improvement within the rangeland agro-ecosystem



Map 55: Potential areas for out-scaling deifferent SLM technologies within four agro-ecosystems in Central Asia (Irrigated, Rainfed, Rangeland and Mountain).

The similarity results shows a various distribution of the four agro-ecosystem, Figure 4 shows the total area (km^2) for each agro-ecosystem in the Central Asian Countries and Figure 5 shows the percentage of each agro-ecosystem in each Central Asian Countries.

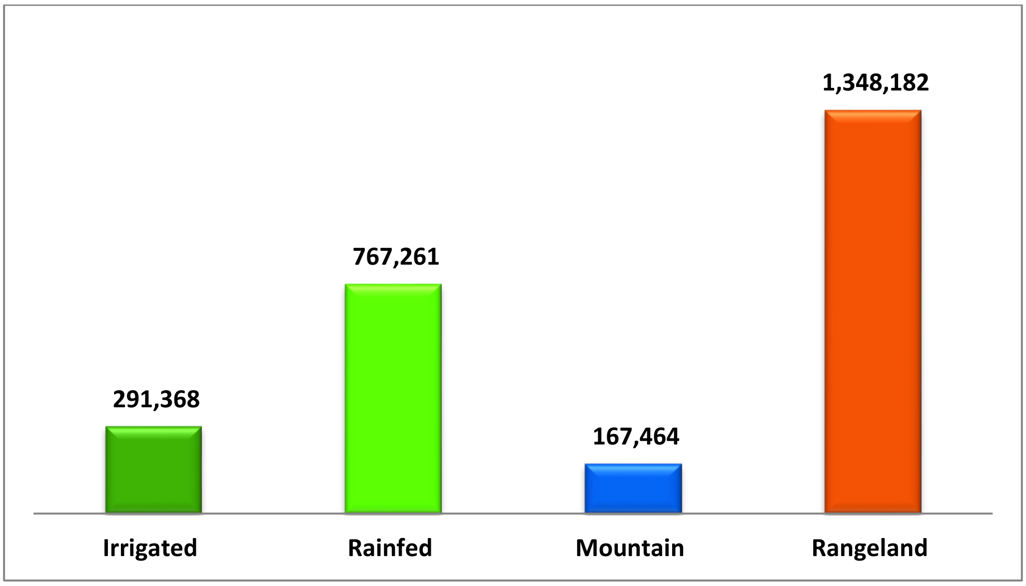
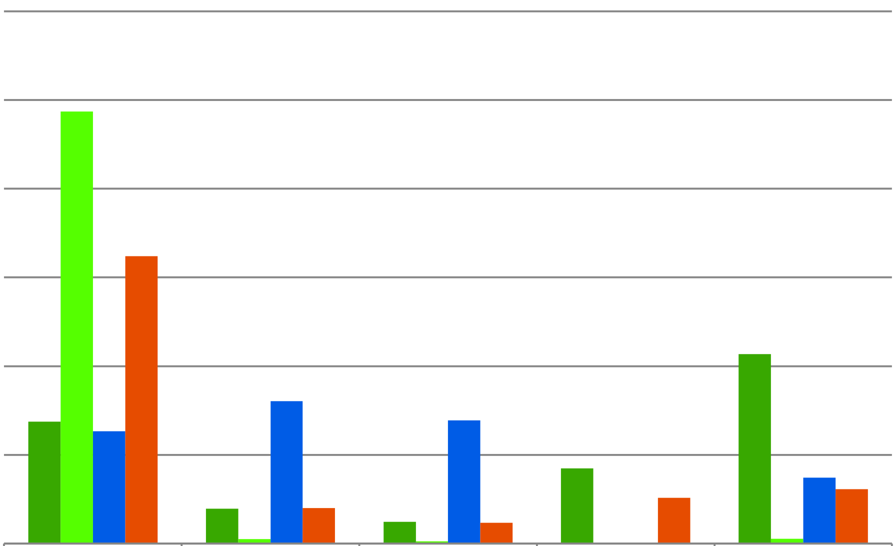


Figure 4: Similarity analysis results: calcualtion of total area (km^2) of each agro-ecosystem



	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Irrigated agro-ecosystem	27.49	7.85	4.94	16.99	42.73
Rainfed agro-ecosystem	97.38	1.03	0.50	0.00	1.09
Mountain agro-ecosystem	25.29	32.08	27.75	0.00	14.88
Rangelands agro-ecosystem	64.81	7.99	4.66	10.31	12.23

Figure 5: Similar area percentage in each Central Asian Countries for each agro-ecosystem

Concluding remarks

The results indicated the distribution and area of potential areas for out-scaling various technologies within the four agro-ecosystems in Central Asia. These information are useful for decision makers at national level to decide the relative importance of each agro-ecosystem within their countries and accordingly the technologies to be out-scaled with high potential of being adopted and used. At regional level, donors and/or development programs can benefit from these results by identifying areas to put more efforts in out-scaling technologies that will lead for optimum impact. Investments could be directed based on these results to maximize the benefits and success of adopting different technologies. Furthermore, these results could help in identifying areas with similar environmental conditions where successful implementation of various technologies could be transferred to maximize the benefits of these programs.

At local level within different countries, farmers, land users and extension services can use these results to identify potential intervention(s) that will maximize productivity and improve livelihoods. This will also help farmers and extension services to seek advice about introducing new technologies from similar areas where these technologies are already implemented. This will help in adapting these technologies for wider range of environmental conditions and better uptake.

The participation of national experts in formulating the original similarity criteria and verifying and fine-tuning these maps benefited the whole process. In one hand, there is more confidence of using these results because local experts indicated their satisfaction of the final results and because upon comparing the regional data with national, higher resolution data, a good level of agreement was concluded. In the other hand, the participation of national experts in this exercise will help in disseminating the results and foster the implementation by decision makers.

In general, these results could provide data to facilitate targeting areas for out-scaling of technologies in various agro-ecosystems. This should lead to more adoption by farmers and land users and therefore an obvious impact of implementing these technologies, which result in improved productivity and livelihood in the target areas.

Appendixes

Appendix 1: list of SLM technologies classified per target agro-ecosystem

Irrigated agro-ecosystem

New technology of developing saline lands (NTOZ 1), (NTOZ 2)
Technology of raised bed planting of crops
Application of nano-agro- ameliorative measures of increasing crop productivity on degraded soils
Contour irrigation
Agrotechnology to improve soil fertility, enriching soil organic matter under irrigation by crop rotation "cotton - winter wheat" with repeated and intermediate crops
Resource conservation innovative technology of irrigation for growing agricultural crops with minimum tillage
Water-saving irrigation technology for cotton production on screened furrow perforated polyethylene film
Establishment of dense intensive fruit tree plantations with regulated pruning and drip irrigation
Subsoil irrigation system with near root moistening for garden crops on saline soils
Conservation-biogas technology and the use of organic waste for biogas production to improve soil fertility and crop yields in farmer households
Agrotechnology to prevent secondary salinity on reclaimed slightly saline soils in irrigated agriculture
Technology to increase the fertility of eroded irrigated soils
New method of planting of crops on beds/ridges in saline conditions of irrigated areas
A method for improving the quality of cotton by irrigation furrow on land damaged by irrigation erosion
Mulching the soil with plastic film
Water saving technology of irrigation
Technology of growing vegetables in greenhouse conditions
Planting of crops into irrigation furrow bottom
Planting of crops between former bottom and ridge of the furrow
Innovative technology of furrow irrigation for to grow agricultural crops
Method of growing own-root sapplings of fruit trees and vineyard
Using artesian saline water for irrigation farming in the Kyzyl Kum

Mountain agro-ecosystem

Growing sainfoin in mountainous agriculture
Growing fodder crops on steep slopes of arid highlands
Irrigation of gardens, vegetables using inexpensive drip irrigation technology
Agroforestry on the basis of gardens (establishment of gardens)
Community based forestry
Improvement of land in arid conditions through the development of high-quality pistachio plantations
Method of irrigation of young garden using bottles
Irrigation of garden crops with the use of local irrigation installations in extreme conditions
Increasing soil fertility considering local resources
Technology of establishment of agroforestry meliorative strips with diagonal-grouped method

Rainfed agro-ecosystem

Holistic Conservation agriculture (zero tillage)
Resource conservation technology of growing cereals in rainfed conditions
Soil conservation minimum soil tillage technology and planting
Growing crops based on minimum and zero tillage on rainfed areas
Zero and minimum tillage of degraded rainfed and irrigated soils, restoration and conservation of soil fertility for crop production
New technology of minimum tillage for growing crops
New method of soil slotting to grow winter wheat
Agrotechnology to optimize the properties of low fertility soils and production of organic fertilizers based on secondary resources
Resource saving technologies for improving the fertility of degraded soils
Crop diversification in rainfed conditions
Technology of ensuring high yields of oil and legume crops on rainfed areas
Methodology of planting with deep soil ripping in rainfed conditions to grow agri crops

Rangeland agro-ecosystem

Technology of space and ground monitoring of ecological-meliorative state of rangelands
Establishment of perennial grass seed plots (Improvement of pastures by subseeding perennial legumes and grasses and establishment of seed plots)
Autumn and early-spring irrigation as a mechanism for pasture improvement in climate change conditions
Technology of growing pasture crops in arid conditions
Rotation of pastures in the desert regions

Appendix 2: Core technologies and technologies options to integrate into core technology

Core technology	Technology options to integrate into core technology
	Irrigated agro-ecosystem
Raised bed technology associated with one or more of the listed technologies to improve irrigation and water saving, soil fertility, reduce soil salinity and control soil erosion on sloped irrigated fields	New technology of developing saline lands (NTOZ 1), (NTOZ 2) Contour irrigation Agrotechnology to improve soil fertility, enriching soil organic matter under irrigation by crop rotation "cotton - winter wheat" with repeated and intermediate crops Water-saving irrigation technology for cotton production on screened furrow perforated polyethylene film Agrotechnology to prevent secondary salinity on reclaimed slightly saline soils in irrigated agriculture New method of planting of crops on beds/ridges in saline conditions of irrigated areas A method for improving the quality of cotton by irrigation furrow on land damaged by irrigation erosion Mulching the soil with plastic film Water saving technology of irrigation Planting of crops into irrigation furrow bottom Planting of crops between former bottom and ridge of the furrow Innovative technology of furrow irrigation for to grow agricultural crops
	Mountain agro-ecosystem
Agroforestry and afforestation through the implementation of structural interventions, such as terraces and stone bunds and intercropping of orchard crop with cover crops, such as Sainfoin and Fodder crops, with minimum tillage, and one or more of the listed technologies to improve productivity, empower the local community, improve soil fertility and reduce land degradation	Growing sainfoin in mountainous agriculture Growing fodder crops on steep slopes of arid highlands Agroforestry on the basis of gardens (establishment of gardens) Community based forestry Improvement of land in arid conditions through the development of high-quality pistachio plantations Method of irrigation of young garden using bottles Irrigation of garden crops with the use of local irrigation installations in extreme conditions Increasing soil fertility considering local resources Technology of establishment of agroforestry meliorative strips with diagonal-grouped method

Core technology	Technology options to integrate into core technology
	Rainfed agro-ecosystem
Conservation agriculture by implementing minimum and zero tillage and associated with one or more of the listed technologies to improve productivity, optimize resources' use, improve soil fertility and crop diversification	Holistic Conservation agriculture (zero tillage) Resource conservation technology of growing cereals in rainfed conditions Soil conservation minimum soil tillage technology and planting Growing crops based on minimum and zero tillage on rainfed areas New technology of minimum tillage for growing crops New method of soil slotting to grow winter wheat Agrotechnology to optimize the properties of low fertility soils and production of organic fertilizers based on secondary resources Resource saving technologies for improving the fertility of degraded soils Crop diversification in rainfed conditions Technology of ensuring high yields of oil and legume crops on rainfed areas
	Rangeland agro-ecosystem
Pasture improvement through the implementation of one or more of the listed technologies to improve the vegetation cover, carrying capacity and reduce degradation and the use of geoinformatics to monitor the status and improvement of rangelands	Establishment of perennial grass seed plots (Improvement of pastures by sub-seeding perennial legumes and grasses and establishment of seed plots) Autumn and early-spring irrigation as a mechanism for pasture improvement in climate change conditions Technology of growing pasture crops in arid conditions Rotation of pastures in the desert regions Technology of space and ground monitoring of ecological-meliorative state of rangelands

Appendix 3: Land use system classes by LADA project

No	Land use classes
15.	Agriculture - large scale Irrigation
16.	Agriculture - protected
17.	Bare areas - protected
18.	Bare areas - unmanaged
19.	Bare areas - with low livestock density
20.	Bare areas - with mod. livestock density
21.	Crops and high livestock density
22.	Crops and mod. intensive livestock density
23.	Crops, large-scale irrigation, moderate or higher livestock density
24.	Forest – protected
25.	Forest – virgin
26.	Forest - with agricultural activities
27.	Forest - with moderate or higher livestock density
28.	Grasslands - high livestock density
29.	Grasslands - low livestock density
30.	Grasslands - moderate livestock density
31.	Grasslands - protected
32.	Grasslands - unmanaged
33.	No data
34.	Open Water - inland Fisheries
35.	Open Water - protected
36.	Open Water - unmanaged
37.	Rainfed crops (Subsistence/Commercial)
38.	Shrubs - high livestock density
39.	Shrubs - low livestock density
40.	Shrubs - moderate livestock density
41.	Shrubs – protected
42.	Shrubs - unmanaged
43.	Sparsely vegetated areas - moderate or high livestock dens.
44.	Sparsely vegetated areas - protected
45.	Sparsely vegetated areas - unmanaged
46.	Sparsely vegetated areas - with low livestock density
47.	Undefined
48.	Urban land
49.	Wetlands - protected
50.	Wetlands - unmanaged

Appendix 4: List of participants

On-the-job training workshop “Development of similarity maps to promote selected SLM packages in Central Asia”, September 16-18, 2014. Bishkek, Kyrgyzstan

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