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Summary/Abstract

The general objective of this research project is to advance our understanding of the current situation on changes in land degradation (LD) and ecosystem services (ES) values loss due to land use and cover change (LUCC) in Uzbekistan (geographically and economically) and to compare the results with previous research findings spatially. As a result, the study observed a significant shift of 1.6 mln ha degradation within rangelands (grasslands to open shrublands) in Uzbekistan's central and southern regions. The results also showed an increased rate of degradation and predicted that if the trend stays the same for the next ten years, the area of open shrublands can increase by about 80% from the 2018 area and occupy an additional 2,500 k ha (6% of the total country area). The results also calculated that the general loss in ES values accounted for a total of 6.66 billion USD or annually 0.66 billion USD in 2020 terms. Upon the results, the study checked and confirmed that seven agroforestry enterprises established for forest protection goals succeeded in protecting forest land from degradation. As the entire region faces enormous challenges in the prevention, mitigation, and reversal of land degradation, this study ultimately aims to advise on further measures that should be taken against LD after the initial assessment of the current situation, drawing attention to the LD tendency due to LUCC.

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Introduction

Land degradation affects more than 29 % of the global area across all agro-ecologies and alters the well-being of 3.2 billion people with negative impacts on agricultural communities' incomes and food security, eventually leading to mass migrations (Le et al., 2014). If this trend continues, 95 % of the Earth's land area could be degraded by 2050, according to the IPBES (2018) research.

The long-term reduction in the productivity of natural vegetative cover over vast territories is one of the most common and visually determined land degradation processes in the Republic of Uzbekistan, one of the Central Asian republics. Uzbekistan is a fast-growing economy, and to achieve economic growth, the country has been intensively using its natural resources, which negatively affected the state of the land. However, the region has serious salinization, erosion, and desertification issues that cause severe land degradation that negatively affect human and ES conditions (Hamidov et al., 2016).

LUCC is one of the main LD indicators representing the result of human-environment interaction within a given area, influenced by climate change processes and socio-economic dynamics (UNCCD, 2019). LUCC assessment requires geospatial mapping of LC classes using methodologies over comparable time intervals. This study used MODIS time series images to spatially assess LUCC between 2009 and 2018 and assessed the shifts geographically and economically.

Numerous proposed efforts to address LD include promoting more sustainable land management (SLM) and investments in better maintenance of irrigation and drainage systems, among others (Gupta et al., 2009; Kienzler et al., 2012; Pender et al., 2009). One of the particular measures was establishing state-funded forestry enterprises (leskhoz), currently 79 of them, for multiple reasons, including afforestation and LD control. The effectiveness of this measure from a LUCC perspective is another research question of this study. To date, there have been several LUCC assessments of PAs within Uzbekistan, i.e. (Juliev et al., 2019), but none focused on forestry enterprises.

Input received from LUCC analysis helps to develop effective strategies and policies and produce land use plans and data for spatial planning. Hence, this study uses LUCC analysis to fill the knowledge gaps in the recent occurrences of LD and help decision-makers achieve sustainable development and interpret the changing environment's tendencies.

Hypothesis and Objectives

The research demonstrates how LUCC shifted between 2018 (end line period) and 2009 (baseline period) in Uzbekistan and assesses the cost of LD from such LUCC. Additionally, the study examines the effectiveness of forestry enterprises from a LUCC perspective and develops suggestions for policymakers and relevant societies.

To investigate these research objectives, the study seeks to answer the following research questions and compare finding with linked hypotheses (Table 1), using the following Research Matrix:

Table 1. Research Matrix in relation to the research questions

Research Question	Hypotheses	Data needed
1. Has LC in Uzbekistan changed in terms of ES values between 2009 and 2018?	LC in Uzbekistan changed negatively in terms of ES values between 2009 and 2018.	- Data on LUCC in 2009/2018
2. Do forest enterprises in Uzbekistan succeed in preventing forest land degradation?	The existence of forest enterprises in Uzbekistan helps to retain forest land from degradation.	- Data on LUCC in 2009/2018 and data on forest enterprises location
3. Are the losses of ES value due to LUCC in Uzbekistan different in the period between 2009 and 2018 compared to 2001 and 2009?	The loss of ES value due to LUCC in Uzbekistan is higher in the period between 2009 and 2018 compared to 2001 and 2009.	- Data on ES values in 2009/2018 and 2001/2009

Source: Author's compilation.

Methods and Results

- Geographical LUCC

To identify LUCC in Uzbekistan, the study used remote sensing data from the Moderate Resolution Imaging Spectroradiometer (MODIS) Land Cover Type Product (MCD12Q1) to map LC at the pixel level (500 m spatial resolution) between 2001, 2009 (baseline periods) and 2018 (end line period). The currently used improved version of MODIS Collection 6 was issued in 2018 with substantial changes and a more precise 500 m resolution that allows the capture of even smaller shifts of LUCC. The raster MODIS maps were processed using the software package R-studio and QGIS; then CSV documents were retrieved in which each pixel was assigned an LC value (MODIS IGBP legend) according to Table 2.

Table 2 shows that the two country's major LC types have been barren land (area proportion of 36%) and grasslands (39%-44%), followed by croplands (10-11%). In terms of changes and dynamics over time, it can be seen that the area of grasslands is gradually decreasing. In contrast, the area of open shrublands is simultaneously increasing (more than double over the period 2001-2018), which represents the process of land degradation since open shrublands in Uzbekistan are less fertile than grasslands and have a lower ES value , based on the ELD study's calculation in (Nkonya, Mirzabaev and von Braun, 2016).

Another key observation is the increasing speed of the shift from grassland to open shrubland. The increase in the area of open shrublands from 2001 to 2009 was 343 kha, which was a 21% rise, and then subsequently from 2009 to 2018, the increased area accounted for 1,498 kha, which is further a 48% increase from the previous 2009 year. This means that if the tendency stays the same for the next ten years, the area of open

shrublands should increase by about 80% from the 2018 area and occupy an additional 2,500 kha (6% of the total country area).

Table 2. LUCC 2001-2009-2018

LUCC 2001-2009-2018											
		2001		2009		2018		Diff 2001 to 2009		Diff 2009 to 2018	
#	MODIS Land Cover	kha	%	kha	%	kha	%	kha	+-%	kha	+-%
7	Open Shrublands	1,284	3%	1,627	4%	3,125	7%	343	21%	1,498	48%
9	Savannas	16	0%	13	0%	21	0%	- 3	-26%	8	39%
10	Grasslands	19,738	44%	18,852	42%	17,444	39%	- 886	-5%	- 1,408	-8%
11	Permanent Wetlands	39	0%	51	0%	81	0%	13	25%	30	37%
12	Croplands	4,689	10%	4,725	11%	4,716	11%	35	1%	- 9	0%
13	Urban and Built-up Lands	1,052	2%	1,054	2%	1,067	2%	2	0%	14	1%
15	Permanent Snow and Ice	5	0%	335	1%	375	1%	330	99%	40	11%
16	Barren	16,077	36%	16,220	36%	16,054	36%	143	1%	- 166	-1%
17	Water Bodies	1,791	4%	1,815	4%	1,807	4%	24	1%	- 7	0%
	Total	**44,691**	100%	**44,691**	100%	**44,691**	100%				

Source: Author's compilation.

Furthermore, the Change Detection Matrix (Table 3) was created to detect the shift within LC types between the initial state (2009) and final (2018).

Table 3. Change detection matrix between initial and final state (2009-2018)

Change detection matrix between initial and final state (2009-2018), kha											
		Final State 2018									
	LC	7	9	10	11	12	13	15	16	17	Total
Initial State 2009	7	1,475.9	-	55.4	-	0.8	-	-	94.8	-	**1,627**
	9	-	9.5	2.7	-	0.2	0.1	-	-	-	**13**
	10	1,609.8	8.4	16,590.1	19.5	202.2	5.1	0.6	414.6	2.2	**18,852**
	11	-	-	5.0	45.3	-	-	0.0	0.5	0.5	**51**
	12	5.6	2.7	193.0	-	4,512.8	8.3	-	1.1	1.2	**4,725**
	13	-	-	-	-	-	1,053.9	-	-	-	**1,054**
	15	-	-	2.5	0.0	-	-	195.0	137.0	0.2	**335**
	16	33.4	0.0	594.2	10.4	0.1	0.0	179.5	15,397.0	5.6	**16,220**
	17	0.4	-	1.2	5.8	-	-	0.2	9.5	1,797.6	**1,815**
	Total	**3,125**	**21**	**17,444**	**81**	**4,716**	**1,067**	**375**	**16,054**	**1,807**	**44,691**
Change Class		**+1,498.3**	+8	**- 1,408.3**	+29.7	- 8.7	+13.5	+40.4	- 165.7	- 7.4	

Source: Author's compilation.
Remark: For the LC numbers interpretation please refer to Table 2.

Apart from minor changes, matching the results of Table 3, only 3 LC types had significant changes: grasslands, open shrublands, and barren land. The most significant change was 1,610 kha of grasslands to open shrublands during this period (Code 10-7). The second major noticeable shift includes a reciprocal transformation of 594 kha barren land to grasslands (Code 16-10) and a 415 kha transformation of grasslands to the barren land (Code 10-16). The third interesting change to be analyzed was a 95 kha change from open shrublands to barren (Code 7-16) since any conversion to barren land represents extreme degradation and loss of value.

The most important question after detecting the shifts within LC types is where regionally this degradation happens. This analysis next looked into the three shifts highlighted above and mapped them visually with green dots for land improvement and red dots for land degradation (Figure 1).

The results in Figure 1a show a 1.6 mln ha shift from grasslands to open shrublands in the central and southern regions (Navoi, Samarkand, and Kashkadarya regions).

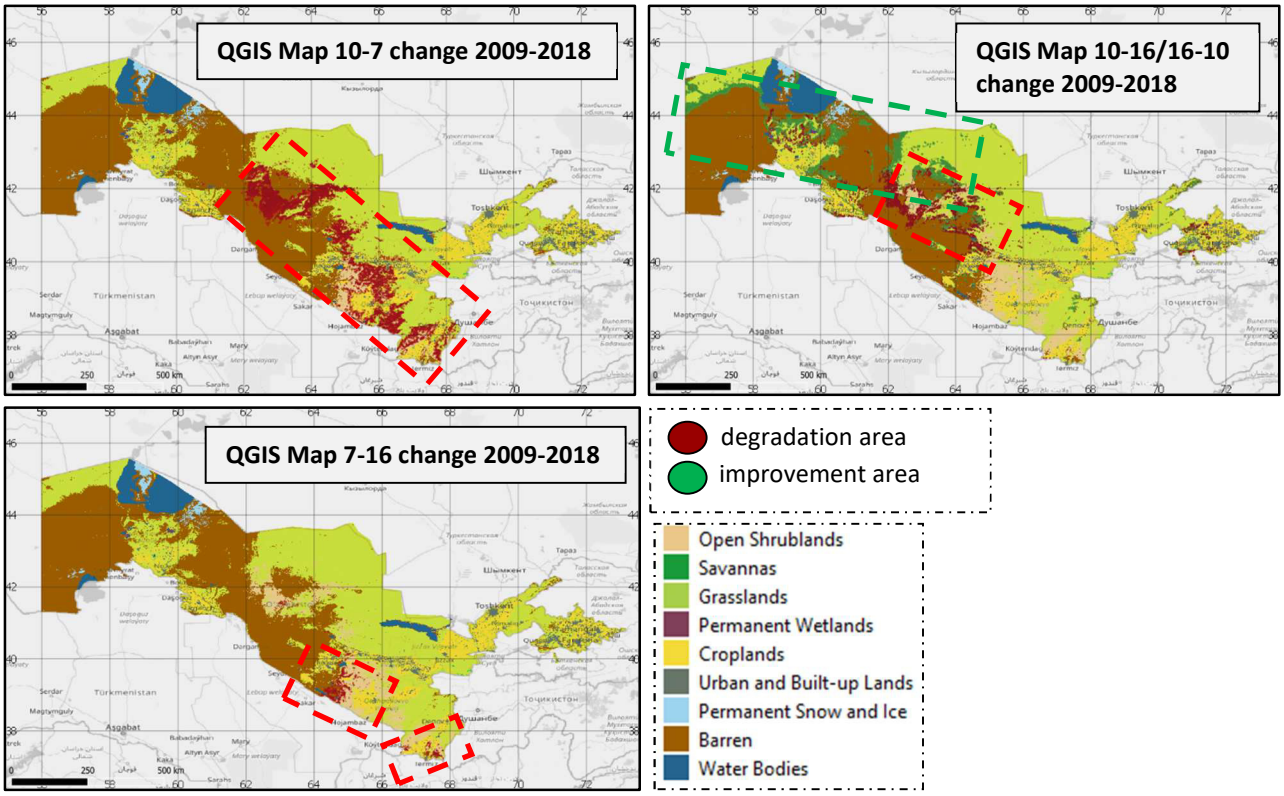

Figure 1. QGIS maps of degradation spots: a) Grasslands "10" to Open Shrublands "7"; b) Barren land "16" to grassland "10" and vice versa "10" to "16"; c) Open shrublands "7" to barren land "16"

Source: Author's compilation using QGIS software.
Remark: Please see the Annex for the larger versions.

Figure 1b depicts a shift of 415 kha from grasslands to barren land (land degradation) on the intersection of the Navoi and Bukhara regions in the desert Kyzylkum and a 594 kha shift from barren land to grasslands (land improvement) happening in the northwestern parts of the Karakalpakstan region and central parts of the Navoi region (central region). Figure 1c shows a 95 kha shift of open shrublands to barren land in the intersection of the Bukhara and Kashkadarya regions, with some minor degradation spots in the south of the Surhandarya region.

Generally, this study's conclusions are consistent with other researchers' conclusions regarding areas of land degradation and predominantly location within rangelands and on the intersections with barren lands.

- LUCC of forestry enterprises

The forestry analysis of this study aimed to detect land cover changes within the chosen forestries' borders and compare them within the analyzed period 2009 - 2018. For that purpose, the data of 7 forestry areas were mapped from publications (Arabov, 2012) for the LC check, including 2 maps combined through the georeferencing procedure in the QGIS platform. The detected areas were analyzed through sampling polygons located inside the forestry areas, and the values were retrieved from MODIS for those areas for 2009 and 2018 years accordingly.

Table 4 summarized the analysis of forestries and showed that in 5 out of 7 forestries, no significant changes were detected, and in 2 forestries located in the Karakalpakstan region, positive changes were detected. This outcome indicates that in terms of LUCC analysis 7 forestries work effectively to preserve and improve the land cover on the protected territory.

Table 4. Forestry analysis

Analysis of 7 forestries						
#	Forestry name	District name	Region Name	Area, kha	Result	Description of the Result
1	Kazahdarinskoe	Muynakskiy	Republic of Karakalpakstan	403	positive changes	8.9 kha of Permanent Snow and Ice changed to 7k ha of Grasslands
2	Muynakskoe	Muynakskiy	Republic of Karakalpakstan	321	positive changes	20 kha of Barren land turned to 19 kha of Grasslands and 1 kha of Wetlands
3	Zhondorskoe	Zhondorskiy	Bukhara region	108	no signif changes	-
4	Farishnoe	Farishniy	Jizzakh region	71	no signif changes	-
5	Kanimekhskoe	Kanimekhskiy	Navoi region	411	no signif changes	4 kha of Grasslands turned to 3 kha of Shrublands
6	Abu Ali ibi Sina	Papskiy	Namagan region	119	no signif changes	-
7	Akhangaranskoe	Akhangaranskiy	Tashkent region	183	no signif changes	-

Source: Author's compilation.

- Monetary value of LUCC

The third objective of the research was to calculate the monetary value of land degradation cost, based on the ELD study's framework methodology (Nkonya, Mirzabaev and von Braun, 2016) and values for each LC assigned by that study during focus group discussions conducted in 2016 in Uzbekistan.

As a result of the calculations, it was concluded that the general loss accounted for a total of 6.66 billion USD or annually 0.66 billion USD in 2020 terms. The net change (the general gain minus the general loss) is negative 3.3 billion USD in 2020 terms during 10 years or 0.33 billion USD annually. This leads to the conclusion that the TEV in Uzbekistan in terms of LUCC has decreased between 2009 and 2018. Practically, all monetary loss happened due to a 1.6 mln ha shift from grasslands to open shrublands. In this regard, more attention should be allocated to rangelands monitoring and support.

Conclusion

The research results show that land degradation costs in Uzbekistan are substantial at about 0.66 billion USD annually between 2009 and 2018, solely from LUCC. Moreover, a negative 3.3 million USD net change of ES value over the ten year period was calculated. This study observed a significant shift of 1.6 mln ha degradation within rangelands (grasslands to open shrublands) in central and south regions. The results also showed an increased rate of degradation and predicted that if the trend stays the same for the next ten years, the area of open shrublands can increase by about 80% from the 2018 area and occupy an additional 2,500 k ha (6% of the total country area).

The limitations of this research include the assessment of LD cost solely due to the LUCC of biomes. These estimates do not account for the LD costs of static land use when the land's productivity declines due to soil and land degradation, leaving land use itself unchanged. Another key weakness of the newer MODIS product used is its 500 m spatial resolution, limiting LC classification and product accuracy. Although the study showed positive results of the effectiveness of forestry enterprises on LC state, more research is needed to draw accurate conclusions on the effectiveness of forestry enterprises using field data research and other applicable on-site techniques.

The study summarizes the recommendations to improve coordination and monitoring of land use systems, including collecting the data on land degradation through contemporary research methods combined with available data. SLM and new skills and knowledge adoption are advised to halt overgrazing and develop integrated land-use planning systems. Also, the study discusses all relevant issues to be addressed within LUCC degradation tendencies. Therefore, it is believed that the results of this LUCC analysis can help decision-makers ensure sustainable development and understand the dynamics of the changing environment.

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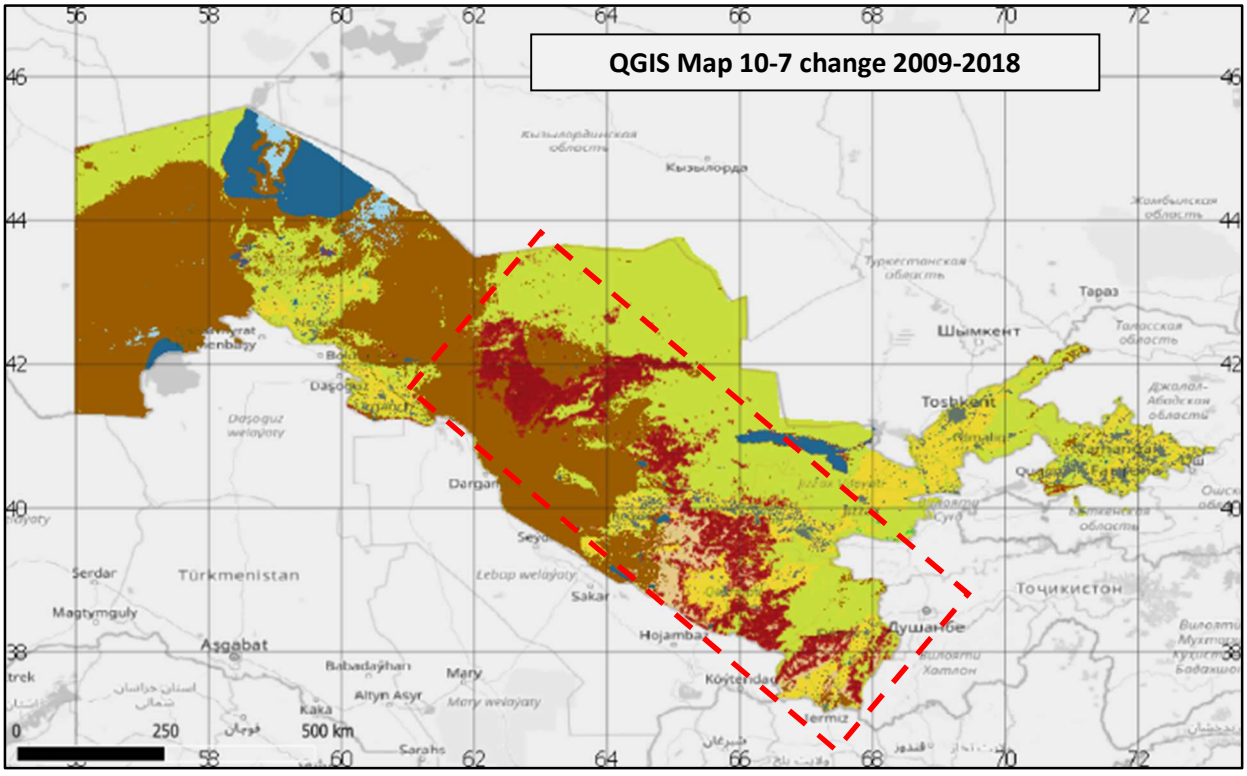
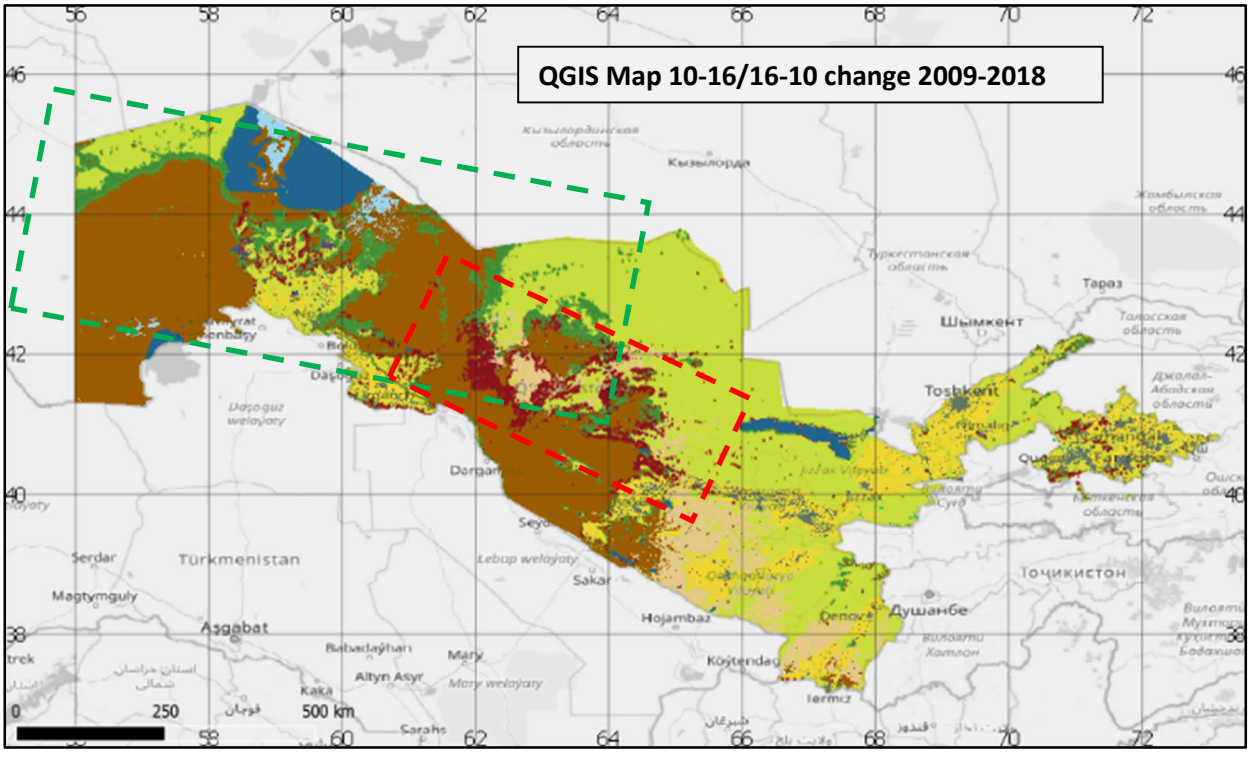
Annex. QGIS maps of degradation spots

Source: Author's compilation using QGIS software

a) Grasslands "10" to Open Shrublands "7"

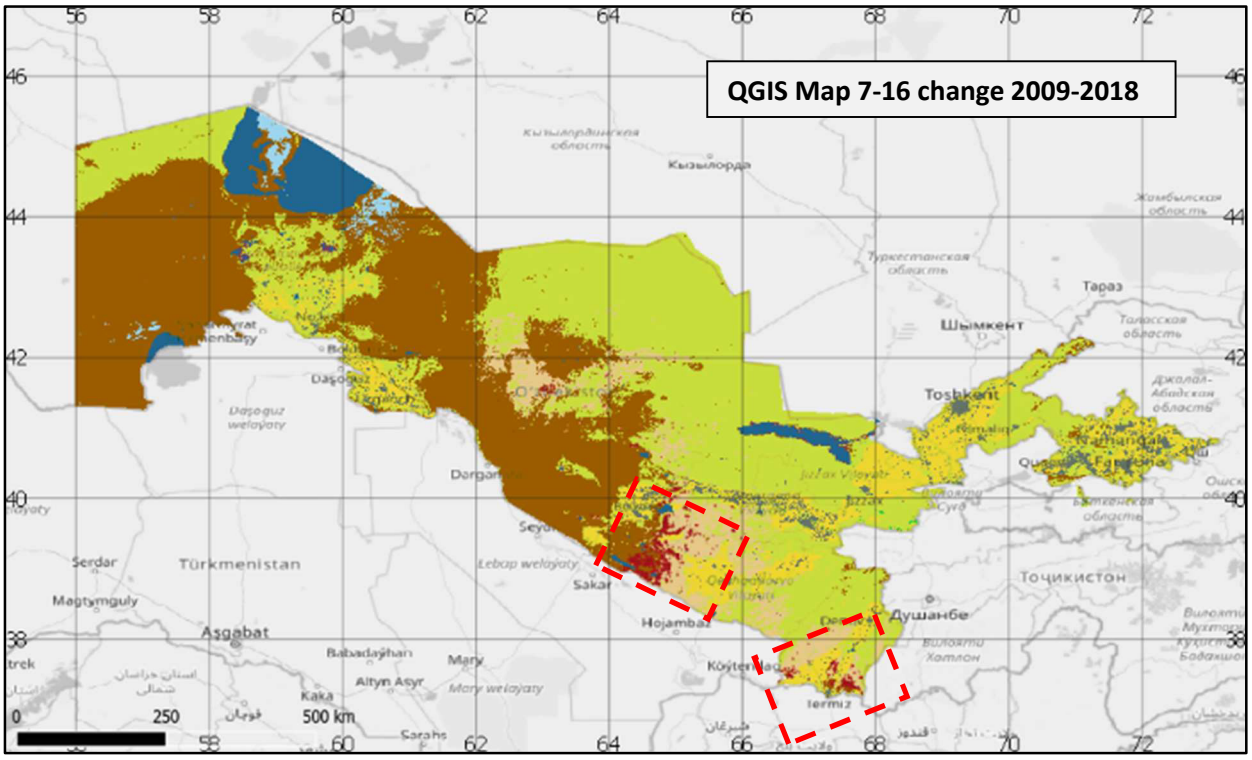


b) Barren land "16" to grassland "10" and vice versa "10" to "16"



Annex (continued)

c) Open shrublands "7" to barren land "16"



- Open Shrublands
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up Lands
- Permanent Snow and Ice
- Barren
- Water Bodies

- degradation area
- improvement area