NELDA TEST SITE REPORT

Kostanay Site (Kazakhstan)

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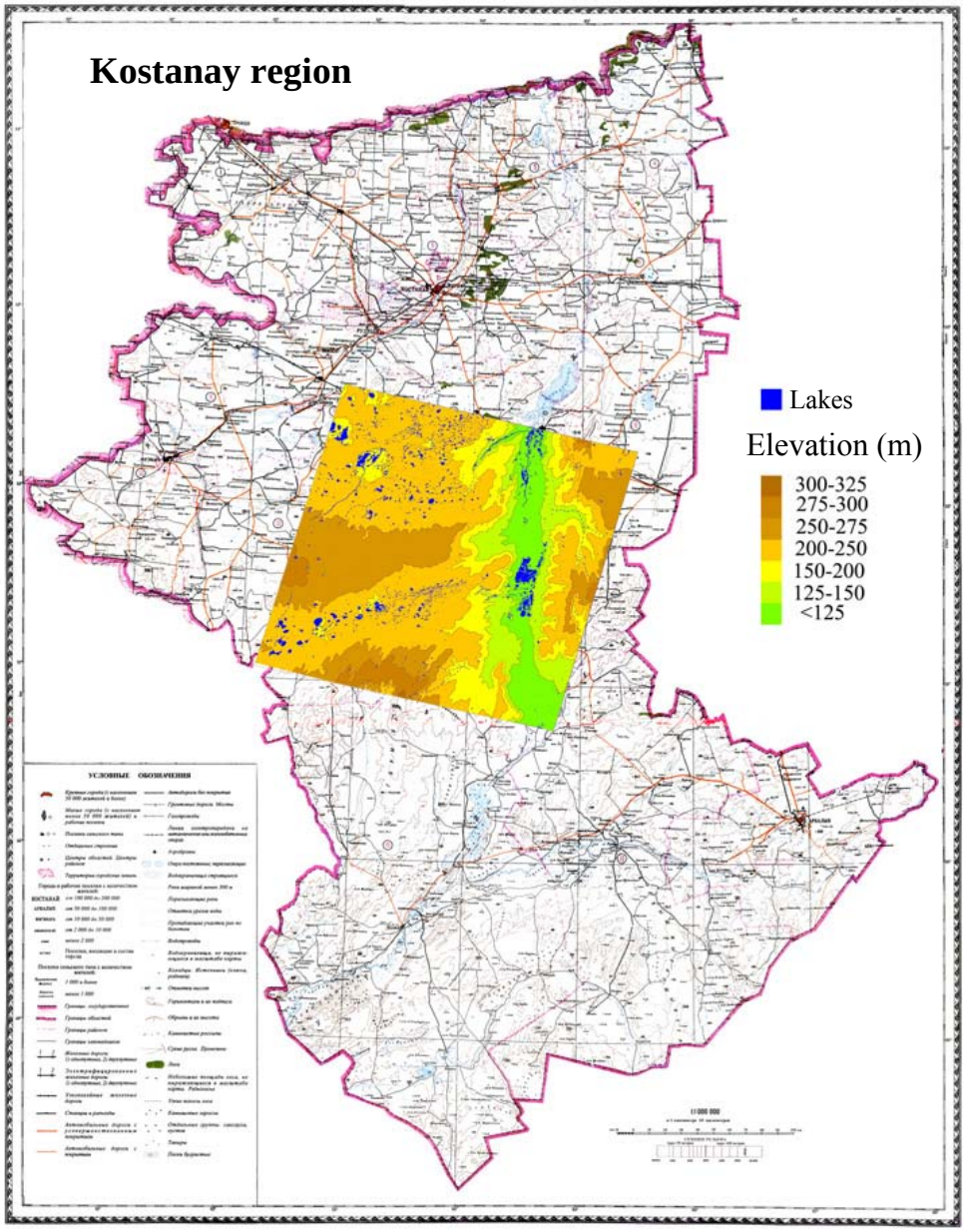
Contents

Site 6 – Kostanay region

1. Site location

a. ***Country, State, Province*** -- Kazakhstan, central part of Kostanay Region (Kostanayskaia oblast).



Center coordinates -- 51°42'14.29"N, 63°46'15.46"E (Landsat 160/24)

2. Physical characteristics of land cover.

The area belongs to Western Siberian climatic province of temperate zone with sharply continental climate. The geographic province is Northern Turgai, which belongs to steppe and dry steppe zones. The terrain is largely flat, with several plateaus ranging in altitude between 250 and 320 meters above the sea level and the wide (30-50 km) bottom of the Turgai valley, which has minimal altitude of 120-125 meters above the sea level. During the last glaciation the intense erosion resulted in wind-blown sand deposition in the middle of Turgai valley where sand dunes and lakes were formed.

The climate of the region is distinctly continental, with hot and dry summers, and cold winters with little snow. Average January temperatures are –17-18◦ C; July averages are +19◦ +24◦ C. The highest temperature on record is +42◦ C, while the coldest on record is -45◦ C. Spring and autumn last about 30 days each. It usually gets above freezing during the first week of April, and gets below freezing during the last week of October. The summer is hot and dry; the winter is cold, without much snow. Average annual temperature is +2.4◦ C. The region gets about 2000-2400 hours of sunlight annually, with the bulk of those hours occurring in summer months. The spring is unpredictable and short, with occasional late cold snaps. Summer weather is primarily clear. July is the warmest month of the year, but even then, cold snaps can occur, with overnight lows dipping to +2, or +3 C. Summer winds are primarily North and North-West, with an average velocity of 4 to 6 meters per second. Windy weather is characteristic for this region. Highest wind speed on record was 20 to 24 meters per second. The region is fairly dry, so the summer months are characterized by droughts, dust storms, and dust swirls. Winter months are characterized by snowstorms. Average annual precipitation, calculated from long-term data, is 250 -300 millimeters. The monthly distribution of the precipitation is very uneven, with the bulk (70 %) of it happening during the summer months. Local vegetation has adapted to the arid conditions. The unpredictability of the precipitation contributes to a relative lack of moisture in the air during summer. The dry period generally begins in the last week of May, and lasts until the first week of September. There are sharp variations in measured annual precipitation, and their timing varies, as well. In winter, the region gets 20 to 40 centimeters of snow cover. The highest measured snow cover was 18 to 36 centimeters in windy places, but in wind-free places the snow cover reached 50 to 70 centimeters. The soil freezes to the depth of 1 to 1.5 meters in areas without snow cover.

Hydrography: The region is bordered by Tobol river to the north, and Turgai river to the south. The stream network functions only seasonally, primarily in spring, flowing from the plateaus to Turgai valley. The largest east-flowing rivers are Dana-Bike (58 kilometers long) and Naurzum-karasu (85 kilometers long); they have well-defined basins which are very deep in the upper reaches. When the snow melts, the water fills up the basins, and upon reaching the lakes, spreads out, flooding the lowlands. Most of the measured annual water flow is quite uneven, with 90% of it belonging to spring run-off on the big rivers and virtually all – on small rivers. The duration and intensity of run-off on small seasonal streams varies year-to-year.

The region has many lakes. The largest ones, located in Turgai Valley, are: Axuat (up to 220 square kilometers when flooded), Sarymoin (126 square kilometers) and Sary-Kopa (336 square kilometers). In Sypsynagashskaya valley there are also many lakes, mostly with salt water. Most of the lakes' basins are shaped like a saucer, where depth rarely exceeds 2.5 to 3 meters. They do not have any inflows or outflows and depend on precipitation for water supply. This leads to very wide fluctuations of the water level and at times the lakes totally dry out. The lakes are classified according to their salinity, with categories like "Sora" with no vegetation, brackish with a narrow

border of reeds, and freshwater lakes, with lush vegetation on the edge. Like most lakes without inflows/outflows in arid and sub-arid regions, the lakes have long multiyear water cycles, which follow the precipitation cycles.

Soils: The region belongs to Kazakh forest-steppe, steppe, and dry steppe provinces of dark-chestnut and chestnut soils. There is marked variation in soil composition, moisture and salinity.

Vegetation: Flora includes elements typical of both northern boreal and temperate vegetation. Forests are predominantly pine (Pinus silvestris), but on the edges, birch and aspens (Betula pendula , B. pubescens , Populus tremula) stands occur. The typical steppe vegetation is composed of dry land herbaceous species (Stipa lessingiana, Festuca sulcata, Galatela tatarica, Tanacetum achillefolium). The eroded sites are dominated by Tanacetum achillefolium, Agropiron cristatum, Psathyrostachus juncea. Communities on sandy soils include Stipa pennata, Gypsophilla paniculata, Asperula danilewskiana. Communities typical of desert zone also occur; these are mostly dominated by low shrubs such as Atriplex cana, Anabasis salca, Artemisia pauciflara, Camphorosma monspeliaca. Steppe shrublands are also common and include Amygdalus nana, Cerasus fruticosa, Rosa spp., Spiraea spp. The herbaceous vegetation of lakes includes reeds (Phagmites australis), cat-tails and other species.

3. Land Use; Major types of vegetation disturbance and land cover change

The land use within the Kostanay study site is represented by agriculture, mostly spring cereals. The majority of croplands are used for grain (wheat and barley) production with use of big fields (typical size 400 ha).

The major types of vegetation disturbance and land cover change are caused by abandoning of cropland, changing of agricultural practice including the parameters of crop-fallow rotation system, wild and anthropogenic forest fire. The climate aridity and great number of small lakes on test site territory gives possibility to estimate the trends climate humidity over the last 20 years. The level of water in lakes varies greatly year-to-year and is strongly linked to weather humidity in a given year.

4. Satellite Imagery

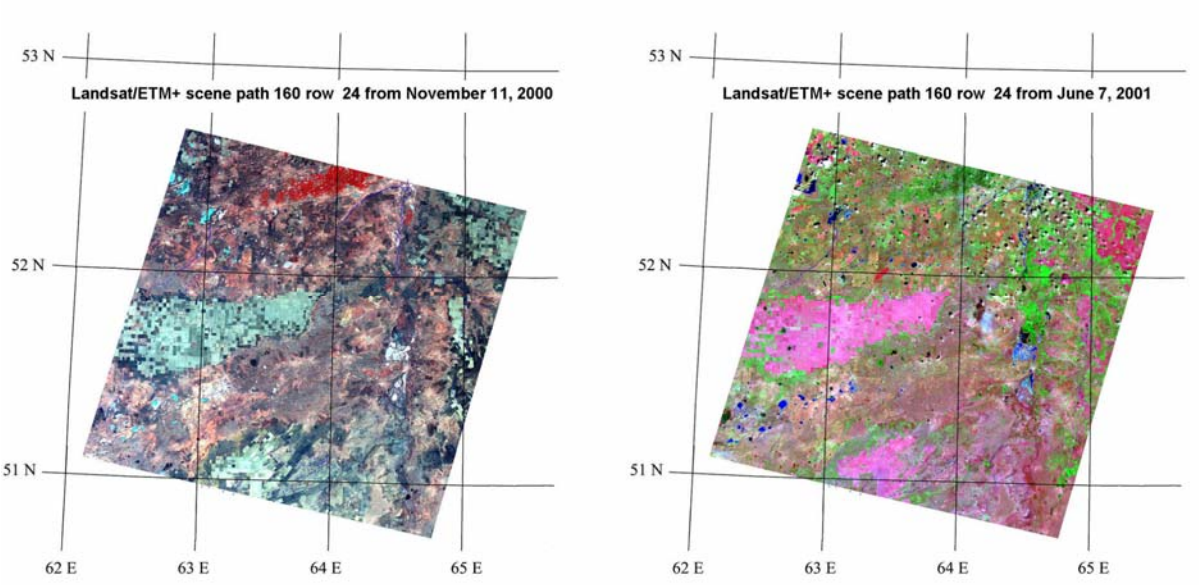
4.1. Landsat imagery

Landsat TM and ETM+ images present the primary source of data for land cover mapping and change detection. The image set includes 4 Landsat images (path/row 160/24) and covers the time period between 1986- 2007 years.

Instrument	Acquisition date	Cloud, shadow	Quality	Use
TM	07/24/1986	4%	9	Change detection
ETM+	11/11/2000	0%	9	Land cover mapping-secondary
ETM+	06/07/2001	3%	9	Land cover mapping -primary
TM	06/16/2007	8%	9	Change detection

4.2 **Imagery Pre-Processing**

The 11-November-2000 and 7-June-2001 Landsat ETM+ scenes (Path 160, Row 24) used for land cover mapping was acquired at level 1G processing with a 28.5-m spatial resolution and UTM projection (zone 41N, WGS84). We used an automated tie-point program from Kennedy and Cohen (2003) to geometrically rectify the image to an orthorectified Landsat scene (Tucker et. al. 2004) with an RMSE within a half-pixel. The 24-July-1986 and 16-June-2007 TM images were first converted to at-satellite radiance using parameters from Chander and Markham (2003) and then to surface reflectance using the COST radiometric correction model (Chavez Jr. 1996). The 2000 ETM+ scene was then radiometrically normalized to the atmospherically corrected TM image using the multiple alteration detection calibration algorithm from Canty (2004). Finally, the six ETM+ reflectance bands were transformed into Tasseled Cap indices of brightness, greenness, and wetness (Crist 1985).



4.3. MODIS imagery

MODIS images were obtained to map the cropland and corresponding crop-fallow rotation system in 2001, 2007 years for change detection 2001-2007 support. It were used cloudless scenes in format of MOD 02 (reflectance, band 1,2 with resolution 250 m). The weather condition of the vegetation season of the various years is different therefore numbers of cloudless satellite images are varied. For example, in 2007 year it was used data by: May 22, 29; June 21,25,30; July 30; August 20,23,25,26,27,31; September 04.

5. Ground Data

Route survey was carried out in late July 2008; various typical land cover types were photographed. Quick Bird image dated August 20, 2007 available at Google-Earth was used to identify tree cover density and urban land cover structure.

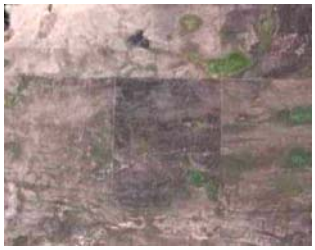
6. Map Legend

a. The following classes were identified as present within the site:

Class_ID	Description	Example	
		Quickbird	Foto
1	Tree.needleleaf.closed		
2	Tree.needleleaf.open		
3	Shrub.broadleaf.open	  	  
4	Shrub.broadleaf.open.built		

5 Herbaceous.closed.cultivated
(cropland, abandoned)

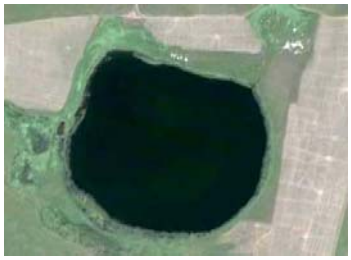
6. Herbaceous.closed
(grassland)



7. Bare.cultivated
(fallow)

8. Bare.sparse
(bare and sparsely
vegetated land)

9 Water



7. Overview of mapping methods

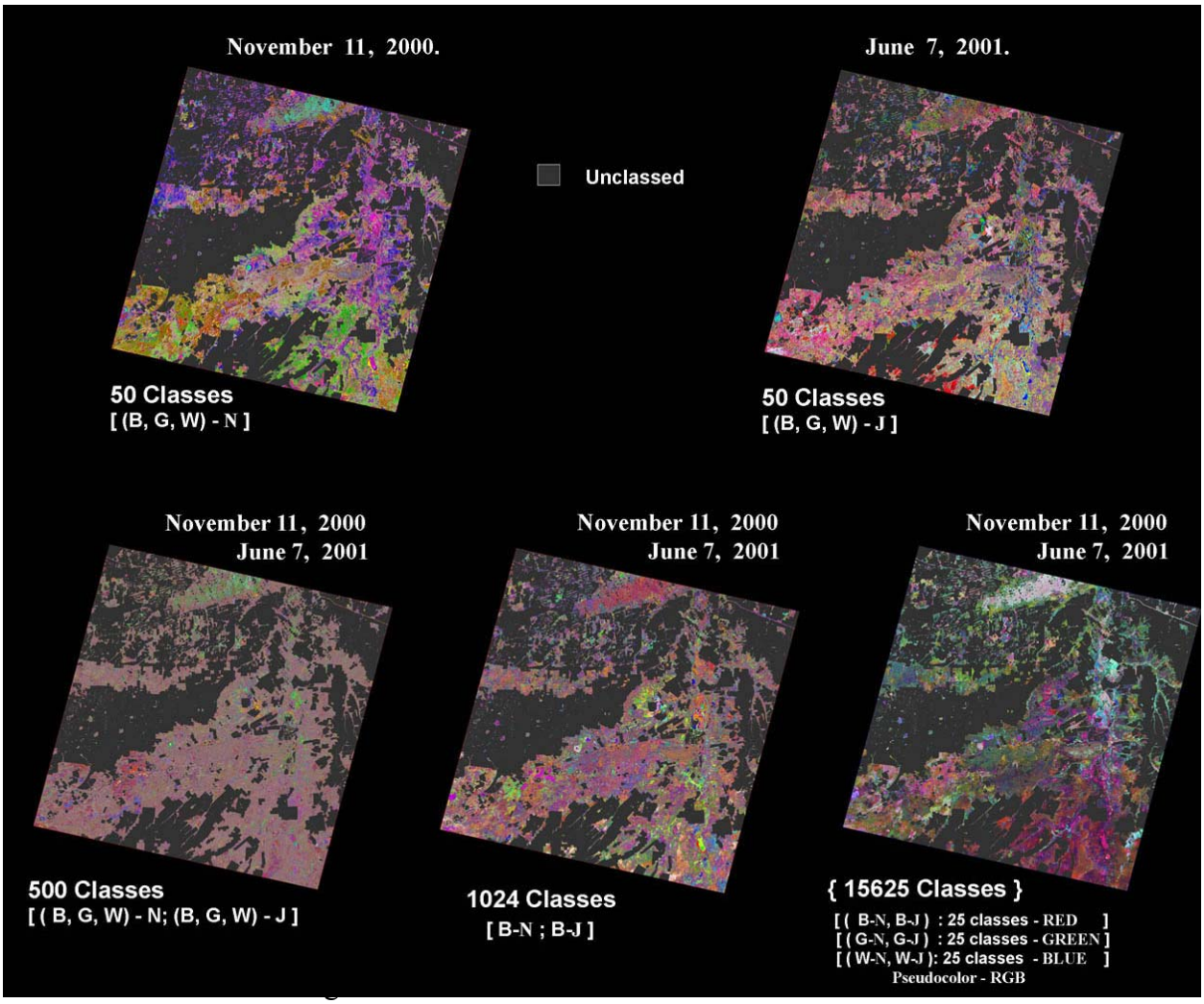
7.1. Create masks

1. Clouds/Shadows – Hand digitized by Landsat ETM+ June 7, 2001.
2. Water – Hand digitized. Water body – stable object which exists on both images, Landsat ETM+, November 11, 2000 and June 7, 2001.
3. Urban territories – Land cover type of ***Shrub.broadleaf.open.built*** has been chosen for all urban cities as the most widespread type of this territory (Quick Bird [Goodle Earht] data).
   1986 - Hand digitized by Landsat TM , July 24, 1986;
   2000 - Hand digitized by Landsat ETM+ November 11, 2000;
   2007 - Hand digitized by Landsat TM , June 16, 2007.
4. ***Herbaceous.closed.cultivated (cropland, abandoned land)*** - Hand digitized by Landsat TM, July 24, 1986
5. ***Bare.cultivated (fallow)*** – joint processing of satellite data with different resolution:
   1986 - Hand digitized by Landsat TM: July 24, 1986
   2001 - Hand digitized by Landsat TM: July 24, 1986 (cultivated land) and MODIS: July and August 2001 daily monitoring (recognition of fallowing type fields);
   2007 - Hand digitized by Landsat TM , July 24, 1986 (cultivated land) and MODIS, July and August 2007 daily monitoring (recognition of fallowing type fields);

7.2. Development of metric for image classification.

The 2000, 2001 Tasseled Cap images were classified into 5 different intermediate products using multiple iterations of ISODATA unsupervised classification.

N	**Input Landsat images**	**Input bands (TC):** **B** – brightness; **G** – greenness; **W** – wetness.	**Number of classes** (ISODATA unsupervised classification)
1	Landsat ETM+ November 11, 2000.	BGW	**50**
2	Landsat ETM+ November 11, 2000, Landsat ETM+ June 7, 2001.	BGW	**50**
3	Landsat ETM+ November 11, 2000, Landsat ETM+ June 7, 2001.	BGW BGW	**500**
4	Landsat ETM+ November 11, 2000, Landsat ETM+ June 7, 2001.	B B	**1024**
5	Landsat ETM+ November 11, 2000, Landsat ETM+ June 7, 2001.	B B	25
		G G	25
		W W	25
	Pseudo color composite RGB – [BB]:[GG]:[WW]		**15625**



List of land cover types from ISODATA unsupervised classification

1 Tree.needleleaf.closed

2 Tree.needleleaf.open

3 Shrub.broadleaf.open

4 Bare.sparse (bare and sparsely vegetated land)

5 Herbaceous.closed (grassland)

Each land cover type made sense crossing some classes from 5 base intermediate ISODATA classifications. Exception was made with part of [shrub.broadleaf.open] land cover type which has been defined by texture analysis. Strip shrub structure (wind protection strips on cropland and abandoned land) was recognized with help of threshold of pixel brightness contrast between original image and smoothing image [kernel 3x3] inside special trip field's mask. Herbaceous.closed (grassland) type is matter of the rest after recognition of others land cover types.

8. Accuracy assessment

8.1. Random selection accuracy assessment of urban territory

Urban territory mask was analyzed by random Landsat pixels selection and analyst interpretation on base of Quick Bird imagery (August 20, 2007).

Bare.built	Herbaceous.closed.built	Shrub.open.built	Tree.needleleaf.open.built	Total
4	4	14	3	25

Most widely widespread [Shrub.open.built] has been carried to all urban territories.
Overall accuracy is : 14/25 = 56,0 %

8.2. Full classification accuracy assessment

Confusion matrices indicate good agreement between the map and test points with class labels determined by expert. The agreement for tree-dominated and herbaceous classes is higher than for other classes. The confusion between Bare and Water classes is attributable to seasonal changes and year-to-year variation in water level of shallow lakes rather than mapping errors. Similarly, the actual confusion between herbaceous and bare may be smaller than the matrix shows. This indicates the limitations of mapping land-cover type as a constant attribute in arid regions.

Accuracy Labels									
Map labels	**B**	**HCC**	**HC**	**SO**	**TNEC**	**TNEO**	**W**	**Total**	**Commission**
B	**9**							**9**	**0,0%**
HCC		**136**	**13**	**6**			**1**	**156**	**12,8%**
HC	**10**	**23**	**119**	**9**			**5**	**166**	**28,3%**
SO	**2**	**3**	**17**	**26**		**1**		**49**	**46,9%**
TNEC	**1**		**1**		**42**			**44**	**4,7%**
TNEO	**1**	**1**	**1**	**1**		**1**		**5**	**80,0%**
W	**25**	**1**			**2**		**34**	**62**	**45,2%**
Total	**48**	**164**	**151**	**42**	**44**	**2**	**40**	**491**	
Omission	**81,3%**	**17,1%**	**21,2%**	**38,1%**	**4,7%**	**50,0%**	**15,0%**		
Overal accuracy				**367 / 491**		**=**	**74,7%**		

8.3. Aggregated classes accuracy assessment

For the accuracy assessment of the aggregated classes random points across the full extent of the classification were selected proportionally to the area of the class but no less than 30 pixels per class. These random points were further assigned by the analyst to one of the 5 aggregated classes based on high resolution Quick Bird images (0.6 m) available at Google Earth.

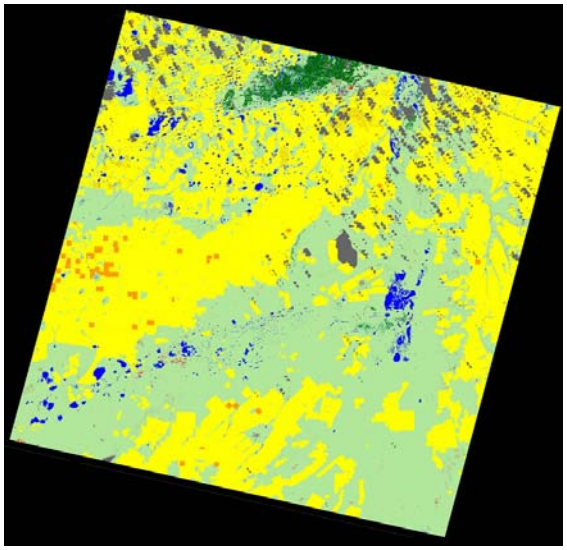
Accuracy label							
Map labels	**B**	**H**	**S**	**T**	**W**	**Grand total**	**Commission**
B	**9**					**9**	**0,0%**
H	**10**	**291**	**15**		**6**	**322**	**9,6%**
S	**2**	**20**	**26**	**1**		**49**	**46,9%**
T	**2**	**3**	**1**	**43**		**49**	**12,2%**
W	**25**	**1**		**2**	**34**	**62**	**45,2%**
Grand total	**48**	**315**	**42**	**46**	**40**	**491**	
Ommission	**81,3%**	**7,6%**	**38,1%**	**6,5%**	**15,9%**		
Overal accuracy			**403 / 491**	**=**	**82,1%**		

Map labels	Commission	Occupied site area	Normalized occupied area (∑100 %)
Bare	0,0 %	0,74 %	0,77 %
Herbaceous	9,6 %	91,56 %	95,01 %
Shrub	46,9 %	0,85 %	0,88 %
Tree	12,2 %	1,39 %	1,44 %
Water	45,2 %	1,83 %	1.90 %

Weighted overall accuracy of the site - 89.43 %.

9. Analysis of mapping results

The final Landsat land cover map is present on the next figure.



LEGEND:

Color	Land cover type	Occupied area (%)
	Tree.needleleaf.closed	0.97
	Tree.needleleaf.open	0.42
	Shrub.broadleaf.open	0.59
	Shrub.broadleaf.open.built	0.26
	Herbaceous.closed.cultivated (cropland, abandoned)	45.11
	Herbaceous.closed.grassland	46.45
	Bare.cultivated (fallow)	0.67
	Bare.sparce (bare and sparsely vegetated land)	0.07
	Water	1.83
	Clouds (shadow)	3.63

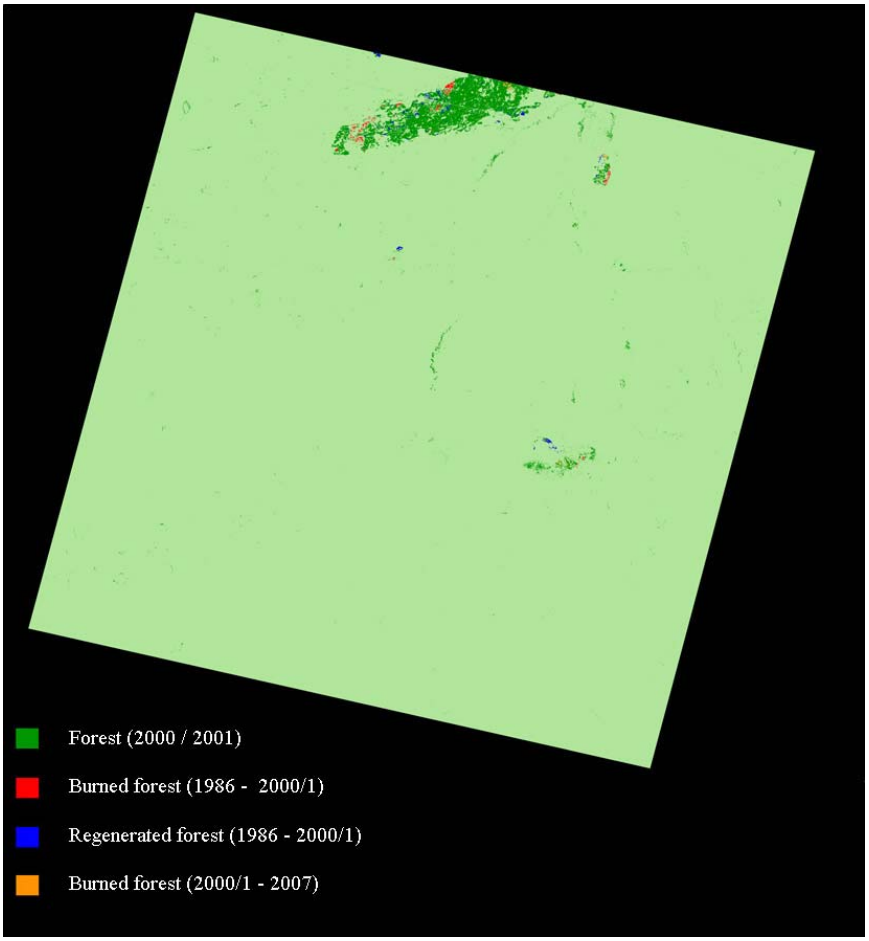
10.Overview of change detection method

The features of land cover types in test site define the change detection method as comparison of hand digitized masks.

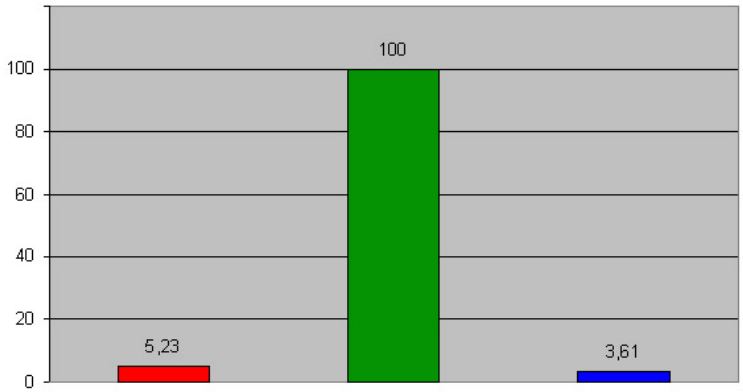
11.Analysis of land cover change

11.1. Forest change.

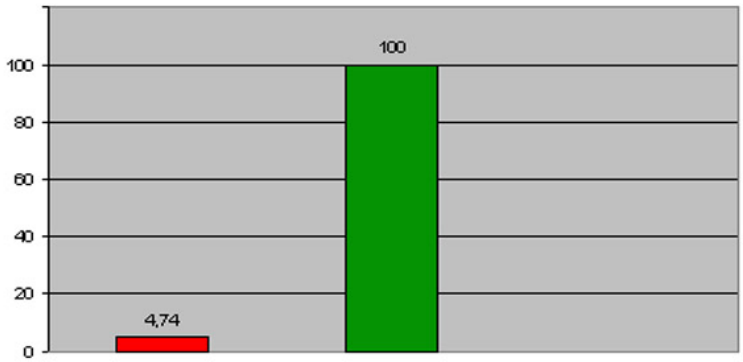
Clear-cut harvest is absent on forest lands. All change related with forest fire and artificial forest regeneration only.



Forest change: 2000/1 against 1986.



Forest change: 2000/1 against 2007.



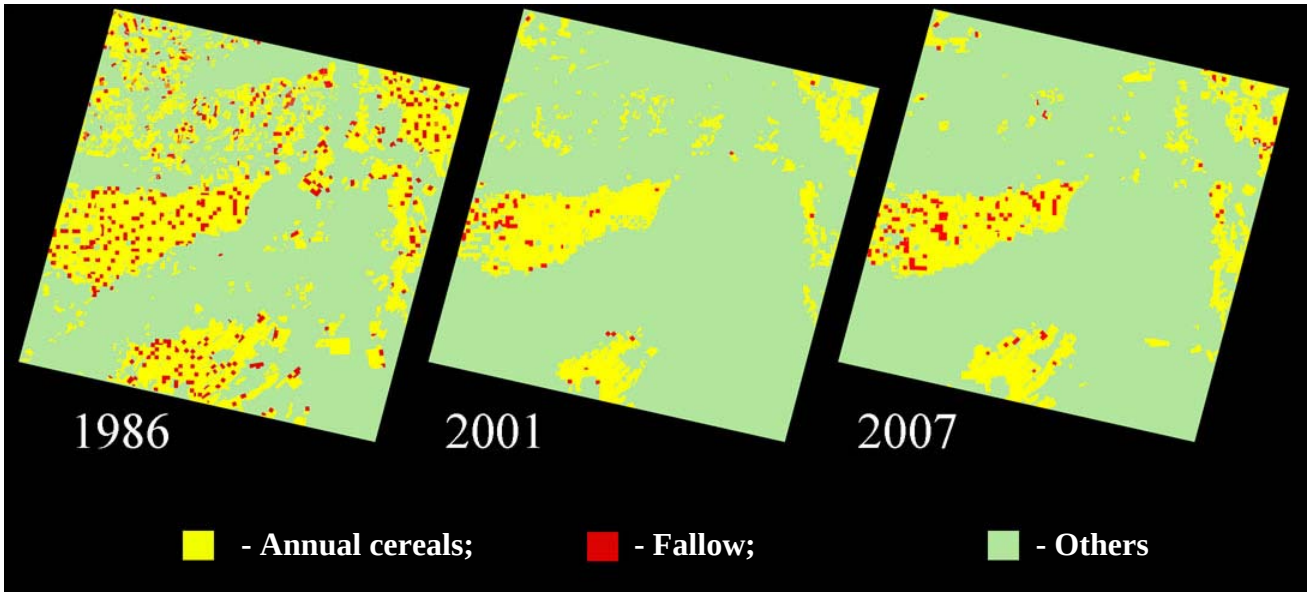
Forest;

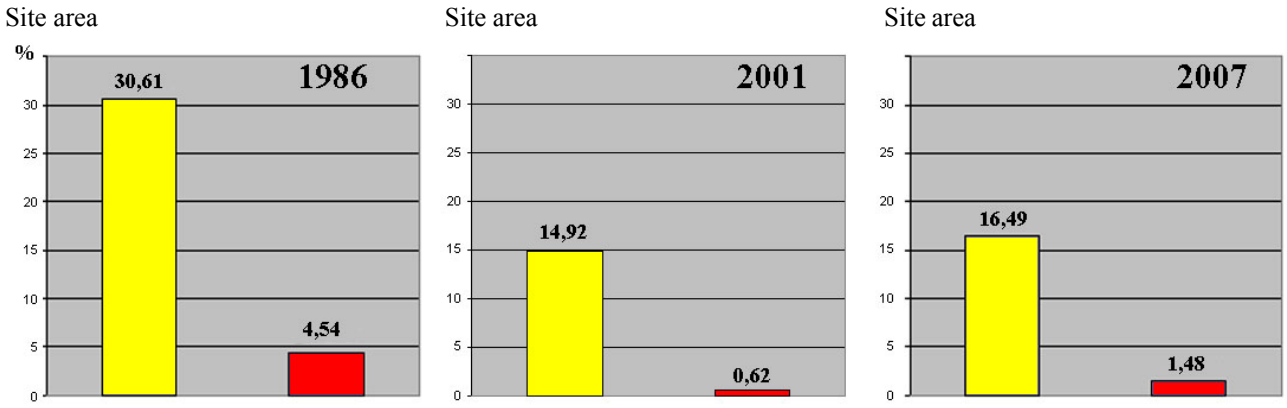
Burned forest;

Regenerated forest.

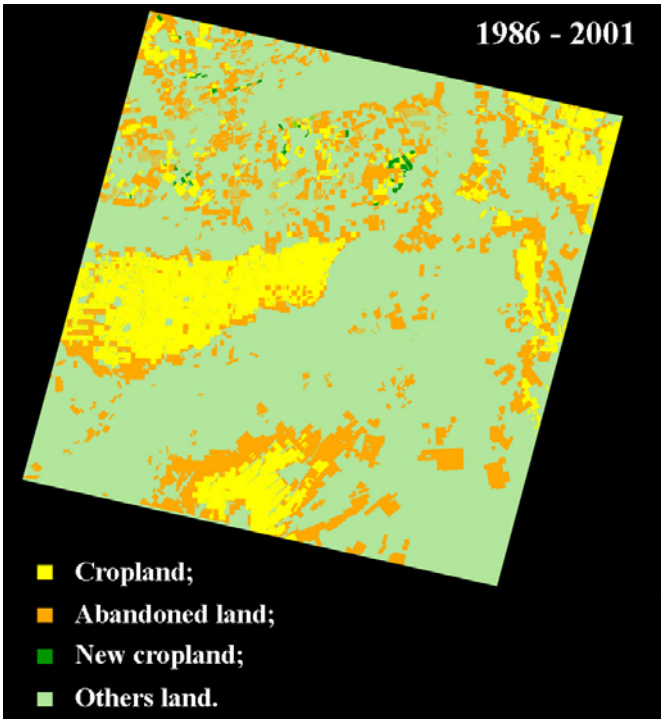
11.2. Agriculture change.

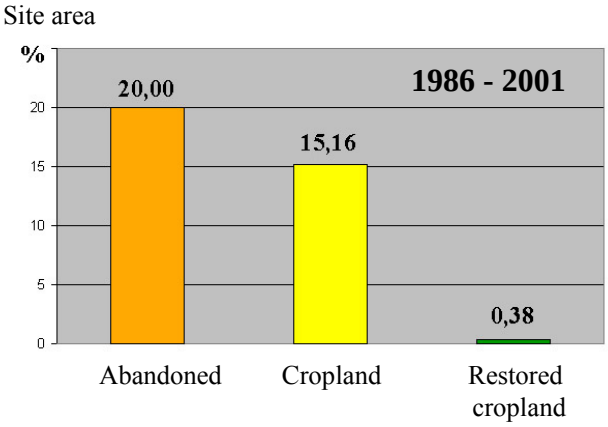
Agriculture system in site is constant during last 50 years. Agriculture change localizes on change of the parameters of the crop-fallow rotation system: cropland and fallow sizes, fallowing part.



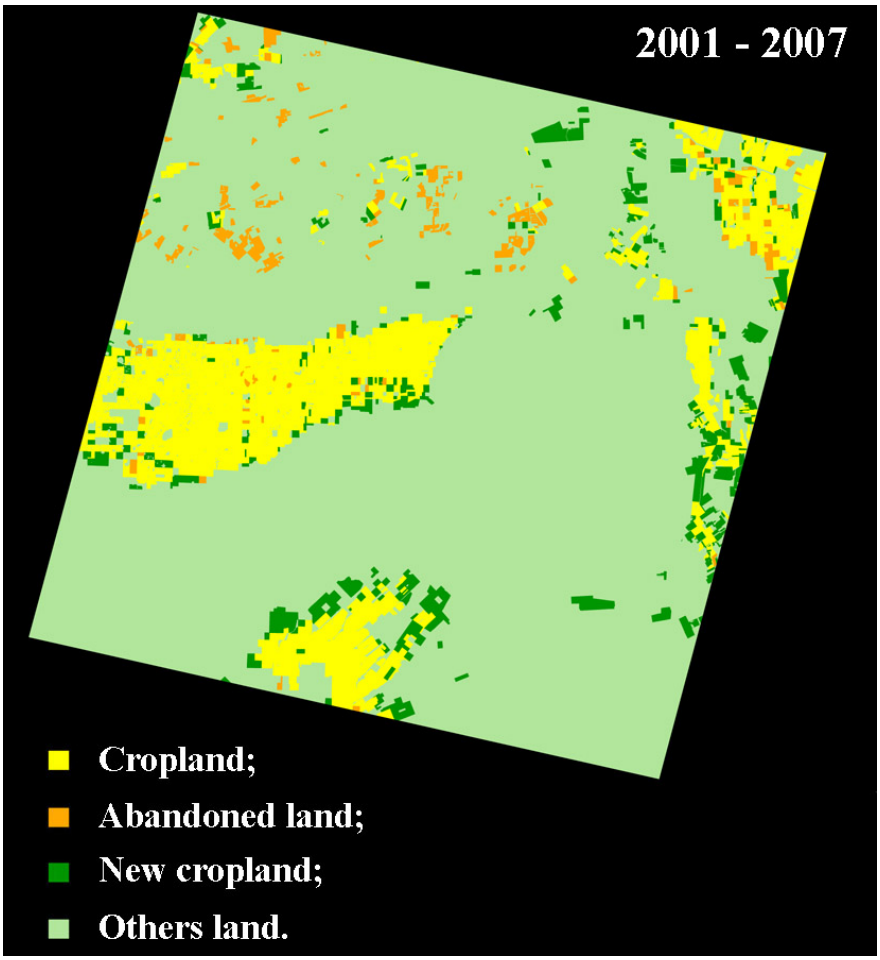


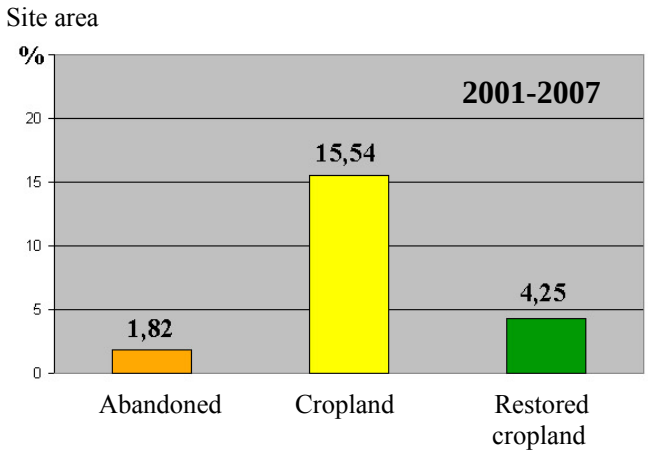
Fallowing: **14,8 %** **4,2 %** **9,0 %**





Areas of cropland, abandoned land and restored cropland (% from site).



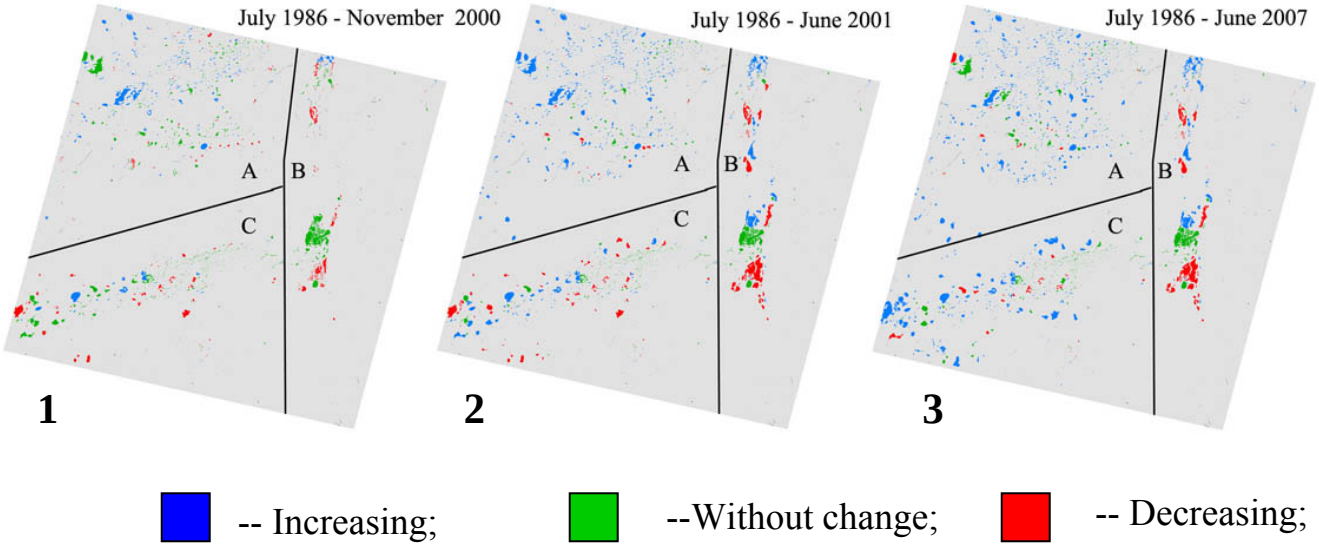


Areas of cropland, abandoned land and restored cropland (% from site).

11.3. Water change.

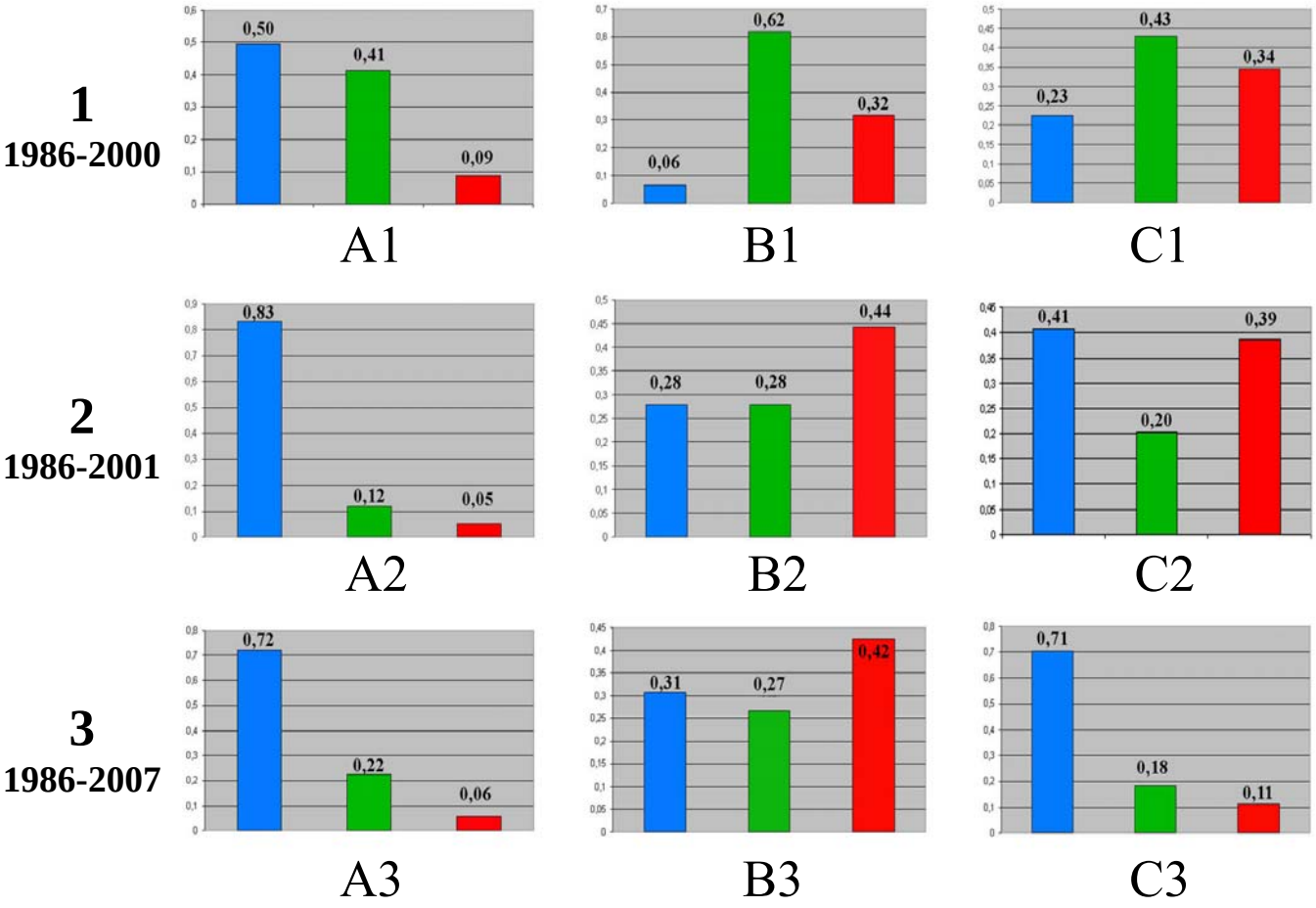
Steppe site landscape includes three lakes systems (A,B,C). Typical lakes this is salt water reservoir with small depth. Lakes size is sensitive on humidity regime (precipitation, ground and underground water resources).

Lakes size changes in framework of zoning (A; B; C):



Zoning of Landsat (path/row 160/24) scene:

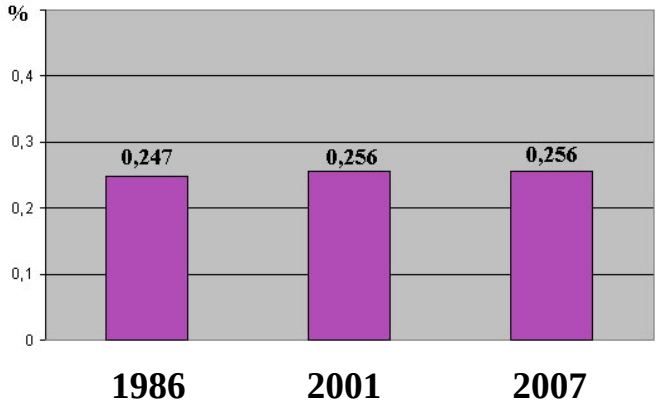
A – The lakes of Tobol-Ubagan watershed;
B – The lakes of Turgay hollow;
C - The lakes of Sypsynagashsky hollow.



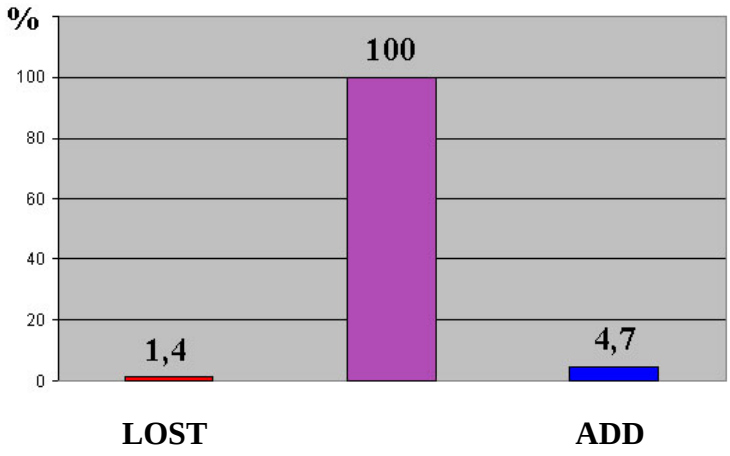
The lakes sizes change for three time period (1: July 1986 - November 2000; 2: July 1986 - June 2001; 3: July 1986-June 2007) in different Landsat scene zones (A,B,C).

11.4. Urban territory change.

Urban territories are presented by small villages. People activity is related with agriculture production basically.



Urban territory areas (% from full scene).



Urban territory change during 1986-2001 (%).

Lost urban - Dismantle of cattle-breeding complexes.
Add urban - Construction of new residential areas.

12 Publications Using the Site Data

Terekhov A.G., et al. (in preparation). Diagnostic of ground humidity of steppe zone in Northern Kazakhstan during 1988-2007 years on base of LANDSAT and NOAA/AVHRR data. Planned for submission to the book ”Modern problems of remote sensing of Earth from space” [rus], 2010.

Terekhov A., Krankina O.. (in preparation). Algorithm of Quick Bird imagery classification in task of estimation of tree cover density. Planned for submission to the J. Computer Optic [rus].

13 List of Contributors to Site Data and Report

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14 Acknowledgements

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15 References

Crist, E.P. (1985). A TM Tasseled Cap Equivalent Transformation for Reflectance Factor Data. *Remote Sensing of Environment* **17,** 301-306.