Soil salinization monitoring using remote sensing data on agricultural lands of the Aral Sea region

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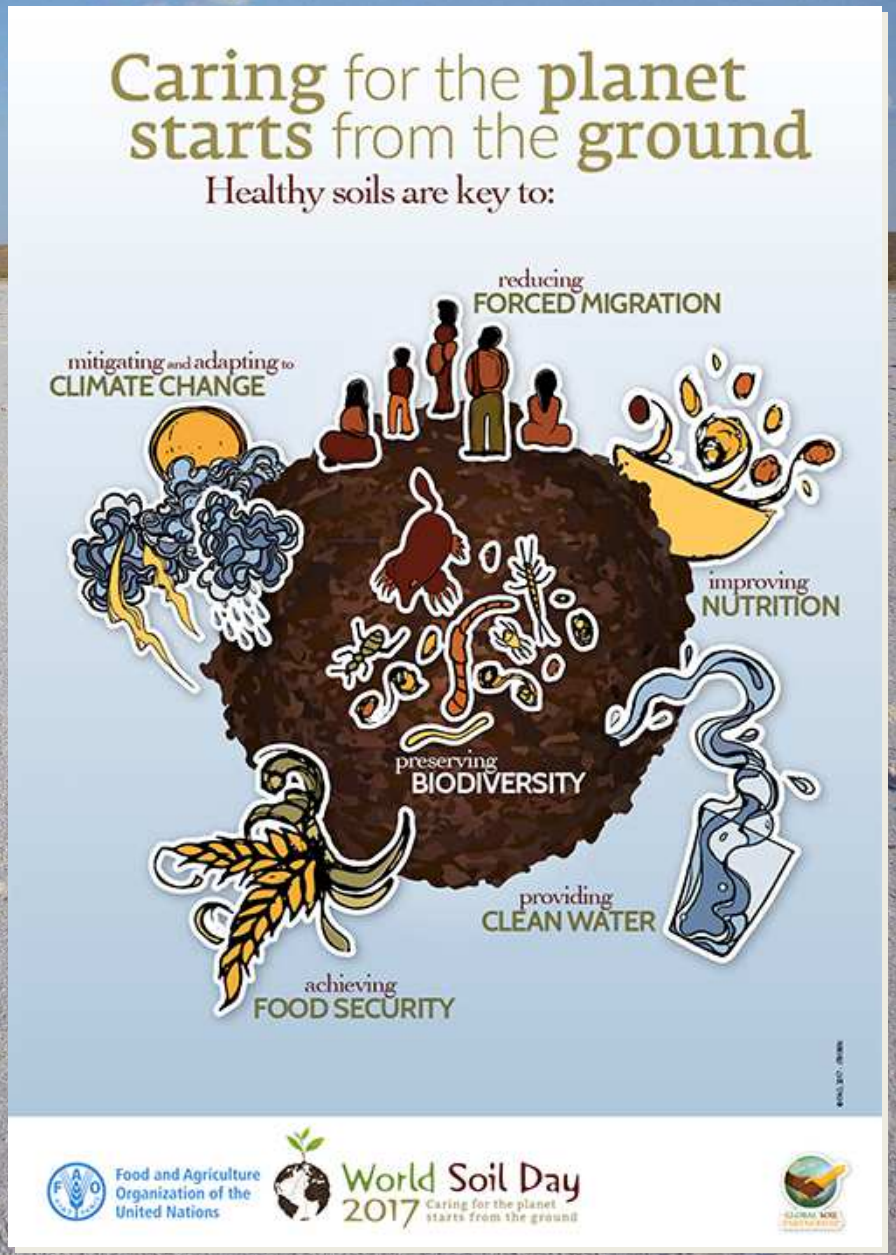
Only 5% of the Earth surface is sustaining crop production !

The areas of cropland in the countries of Central Asia:

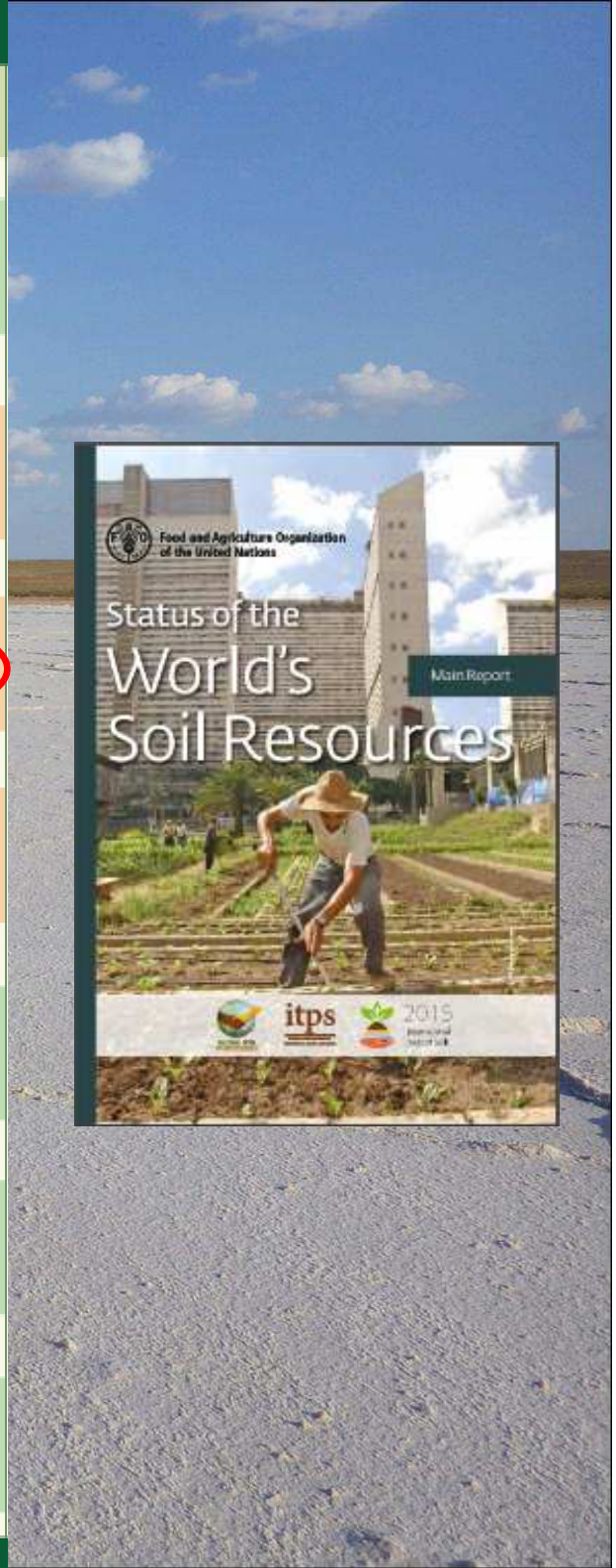
Country	Percent of country's area
Tajikistan	1.0
Uzbekistan	0.9
Kyrgyzstan	0.4
Turkmenistan	0.1



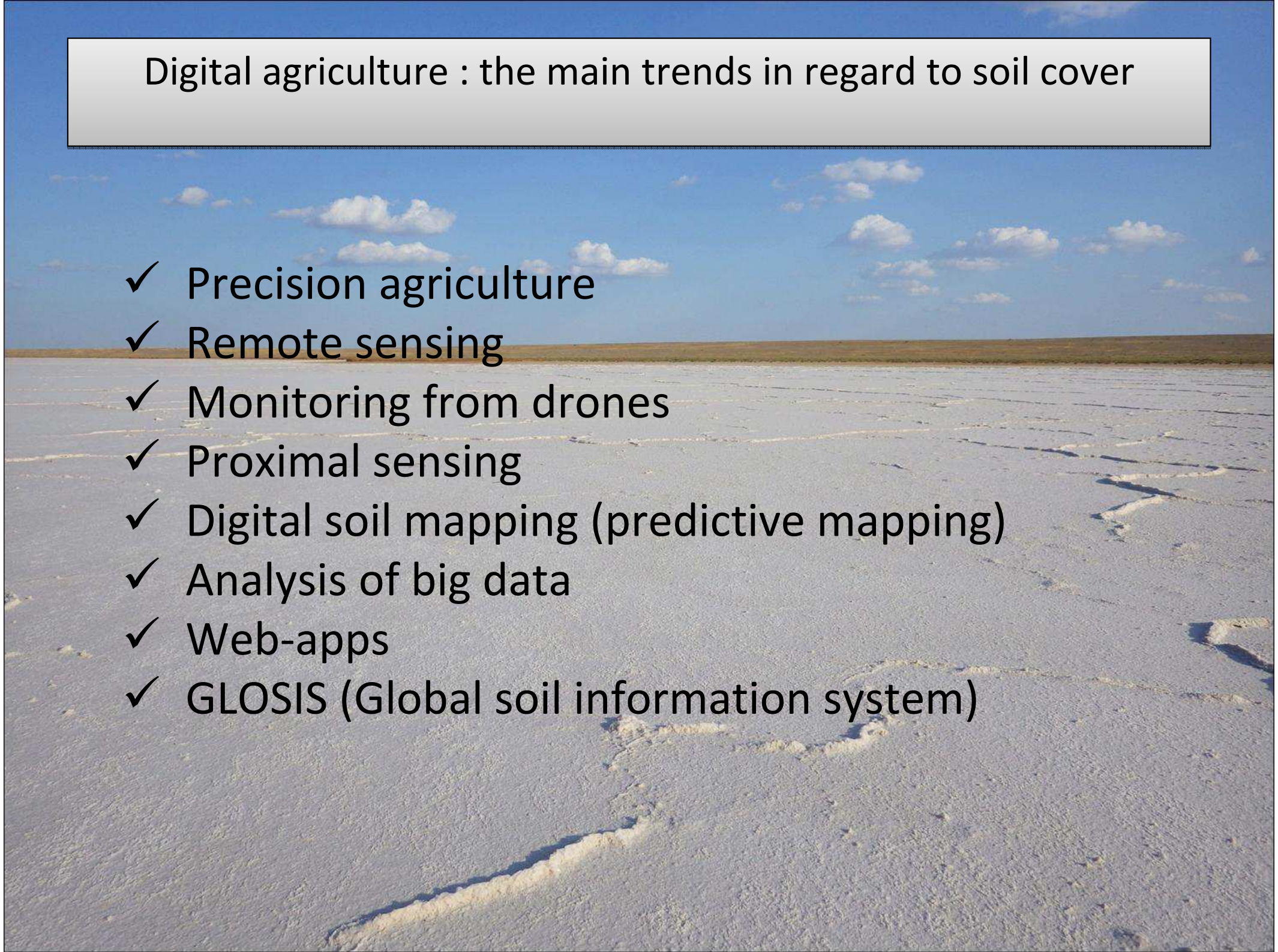

Voluntary Guidelines for Sustainable Soil Management
Soil erosion
Loss of organic carbon
Soil pollution
Nutrient imbalance
Salinization, sodification, alkalization
Major threats to soil security
Degradation of soil structure
Loss of soil biodiversity
Soil sealing
Compaction
Acidification

Global Summary of Threats to Soil Functions

Region	Soil erosion	Organic carbon change	Nutrient imbalance	Salinization	Soil sealing	Loss of biodiversity	Soil pollution	Acidification	Compaction	Water-logging
Sub-Saharan Africa	Poor ↘	Poor ↘	Poor ↘	Fair ↗	Good =	Fair ↘	Good ↘	Poor ↗	Good =	Good =
Asia	Poor ↘	Poor ↗	Poor ↘	Poor ↗	Poor ↘	Fair ↗	Poor ↘	Poor ↘	Poor ↘	Fair ↘
Europe and Eurasia	Fair ↗	Poor ↗	Poor ↗	Poor ↘	Poor ↘	Fair ↘	Poor ↗	Poor ↗	Fair ↗	Fair ↗
Latin America and the Caribbean	Poor ↘	Poor ↘	Poor ↘	Poor ↘	Fair ↗	Poor ↘	Fair ↗	Fair ↗	Poor ↘	Fair =
Near East and North Africa	Very Poor ↘	Poor ↘	Good ↗	Fair ↘	Very Poor ↘	Poor ↘	Very Poor ↘	Good ↗	Poor ↘	Good ↗
North America	Fair ↗	Fair ↗	Poor ↘	Good ↗	Fair ↘	Good ↗	Good ↗	Poor ↘	Fair ↗	Good ↗
Southwest Pacific	Fair ↗	Fair ↗	Fair ↘	Good ↗	Good ↘	Good ↗	Good ↗	Fair ↘	Fair ↗	Good ↗



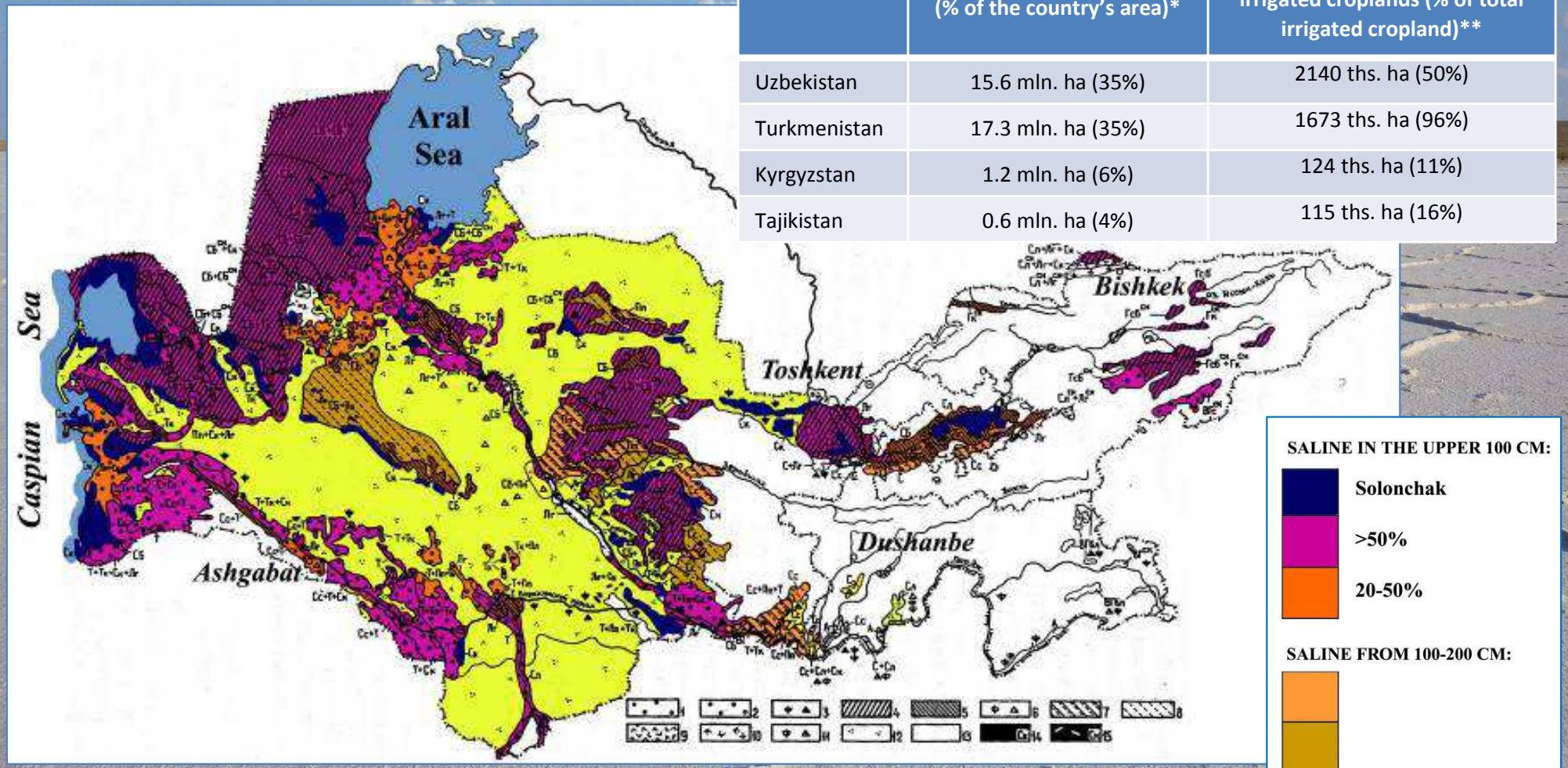
Digital agriculture : the main trends in regard to soil cover



- ✓ Precision agriculture
- ✓ Remote sensing
- ✓ Monitoring from drones
- ✓ Proximal sensing
- ✓ Digital soil mapping (predictive mapping)
- ✓ Analysis of big data
- ✓ Web-apps
- ✓ GLOSIS (Global soil information system)

The distribution of salt-affected soils in the countries of Central Asia

Country	Area of salt-affected soils (% of the country's area)*	Area of salt-affected soils at the irrigated croplands (% of total irrigated cropland)**
Uzbekistan	15.6 mln. ha (35%)	2140 ths. ha (50%)
Turkmenistan	17.3 mln. ha (35%)	1673 ths. ha (96%)
Kyrgyzstan	1.2 mln. ha (6%)	124 ths. ha (11%)
Tajikistan	0.6 mln. ha (4%)	115 ths. ha (16%)

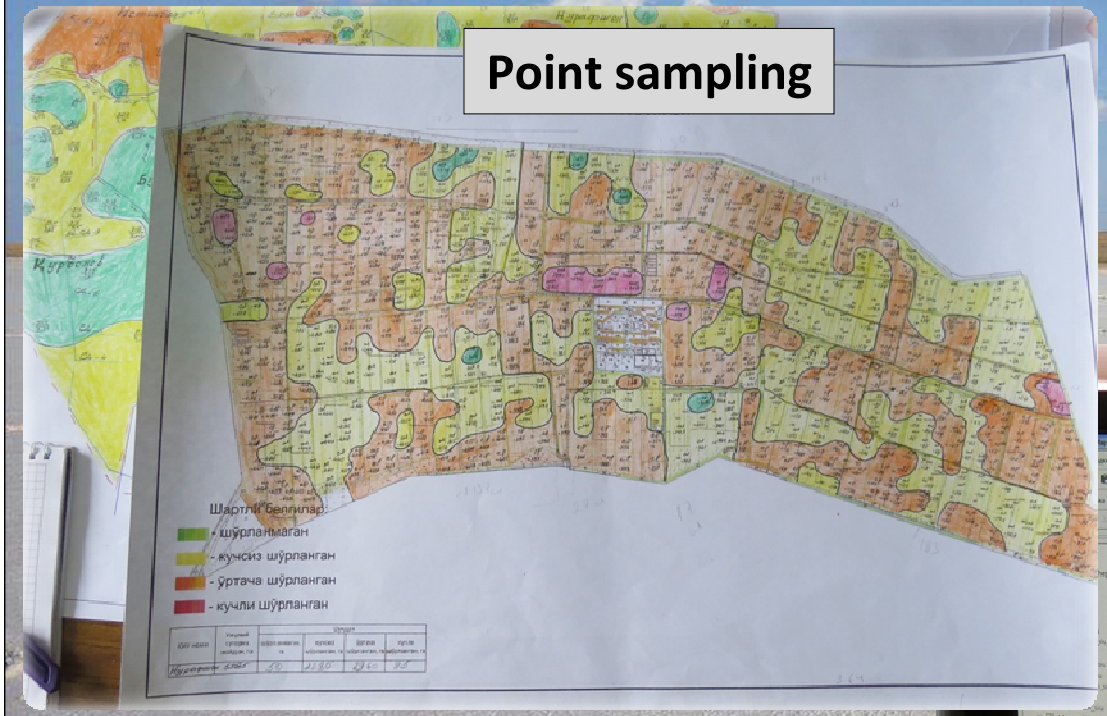


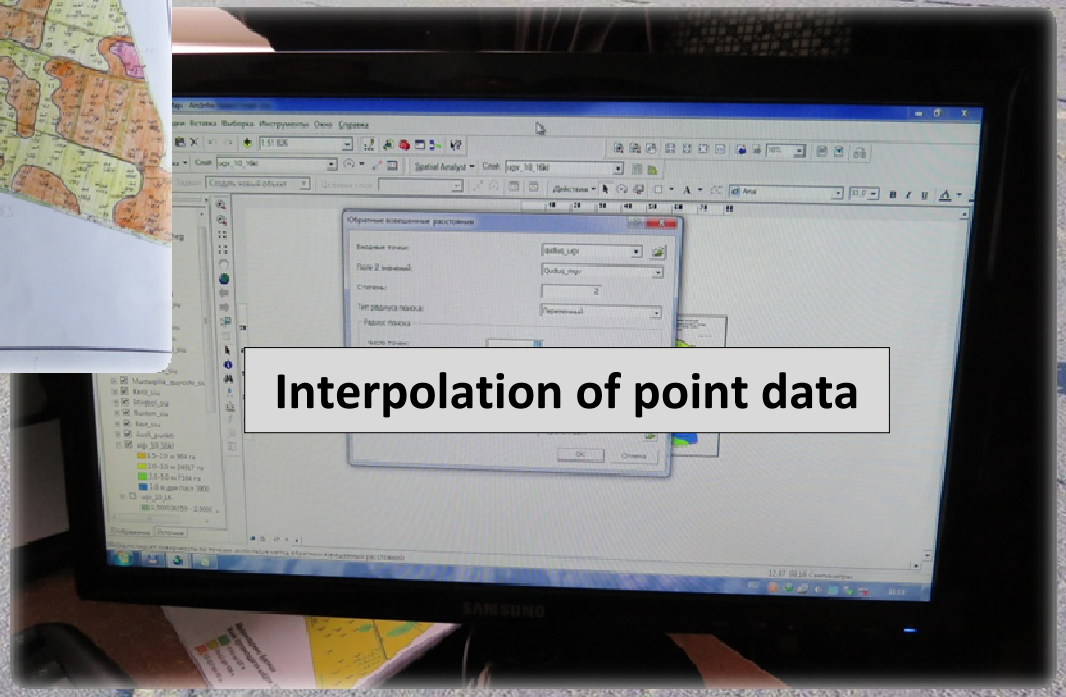
*Source: Vargas et al. (Eds.) 2018. *Handbook for saline soil management*. FAO: Rome.

**Source: Bucknall et al. 2003. *Irrigation in Central Asia: Social, Economic and Environmental Considerations*. World Bank: Washington.

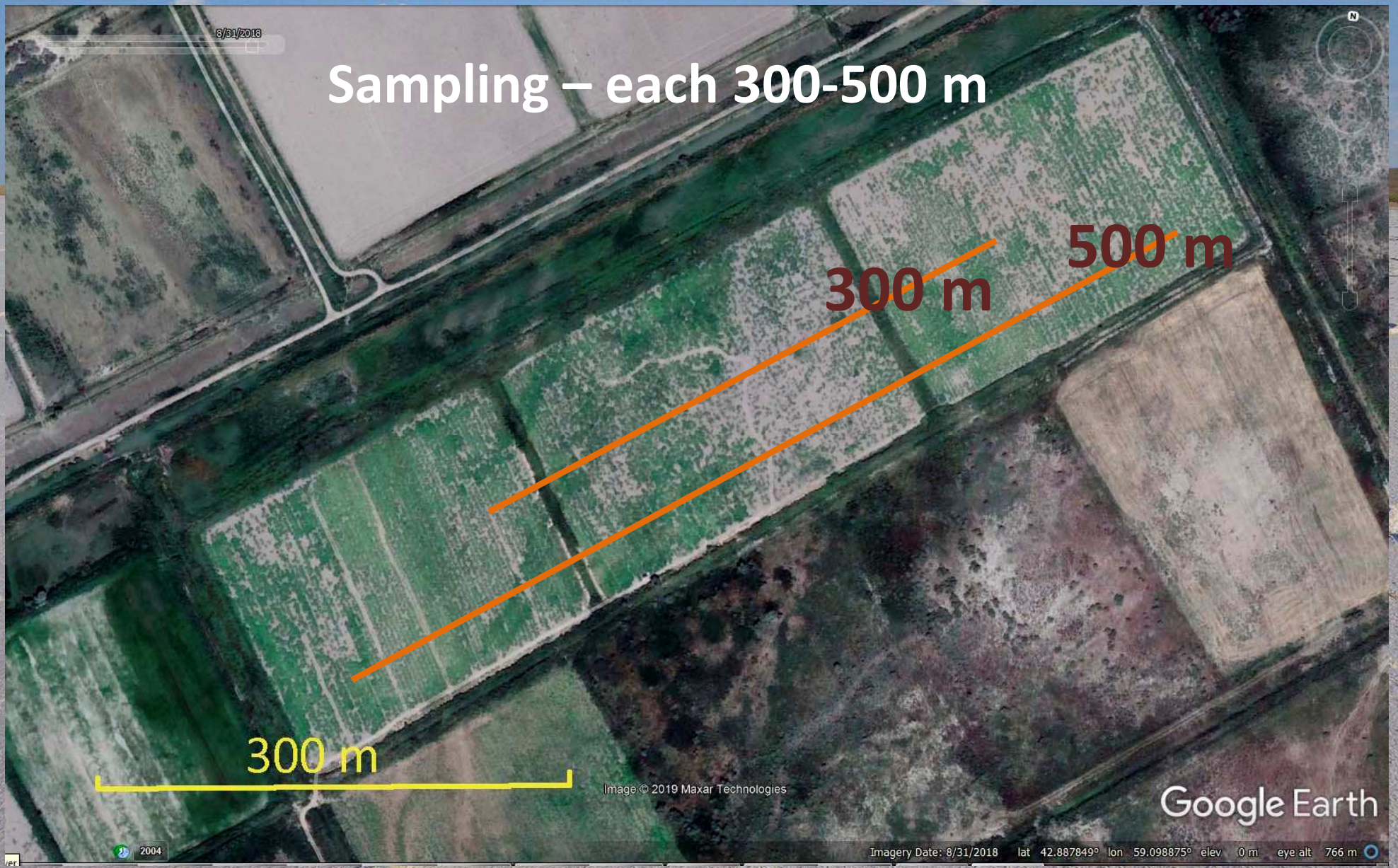
Map source: Pankova Ye.I., Aidarov I.P., Yamnova I.A., Novikova A.F., Blagovolin N.S. *Natural and Human-Induced salinization in the Aral Sea Basin*. Moscow, 1996

The procedure of soil salinity monitoring according to national standards

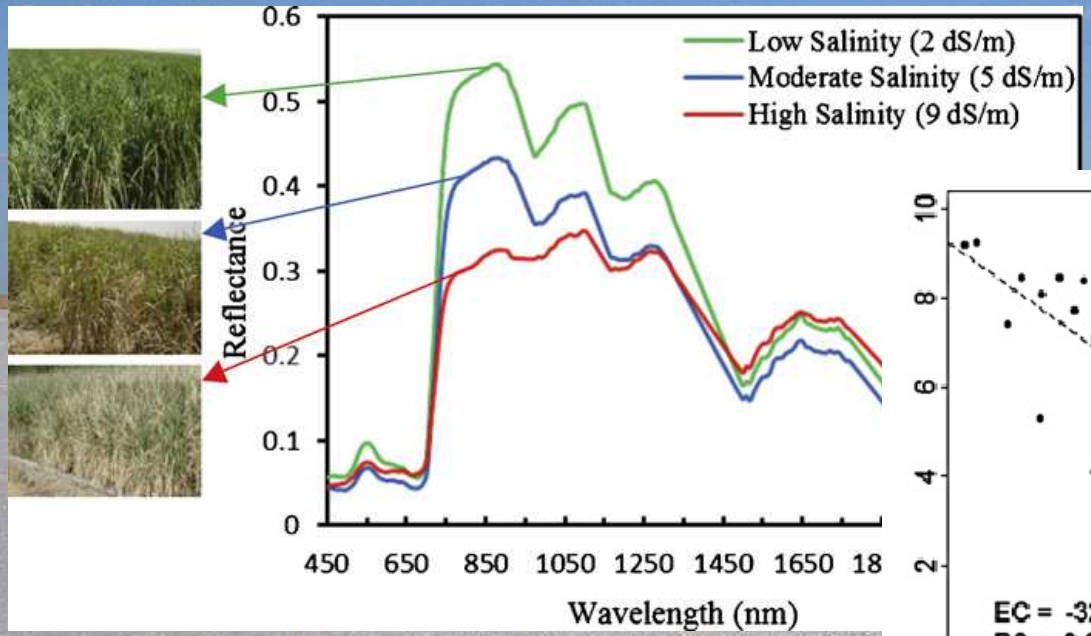




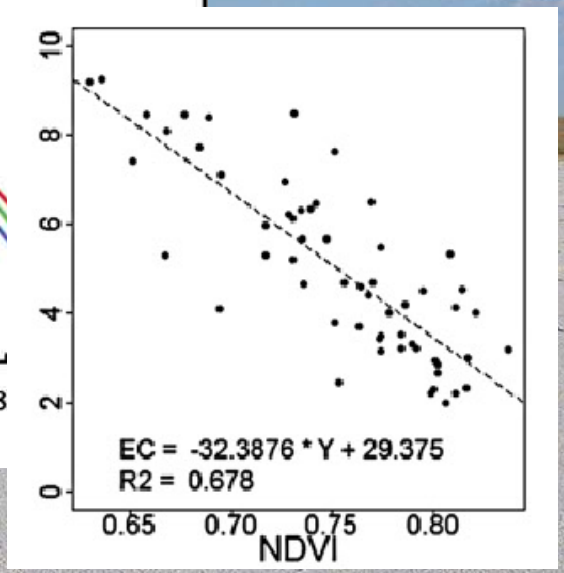
Soil and plant heterogeneity within one field (imagery fragment in Karakalpakstan)

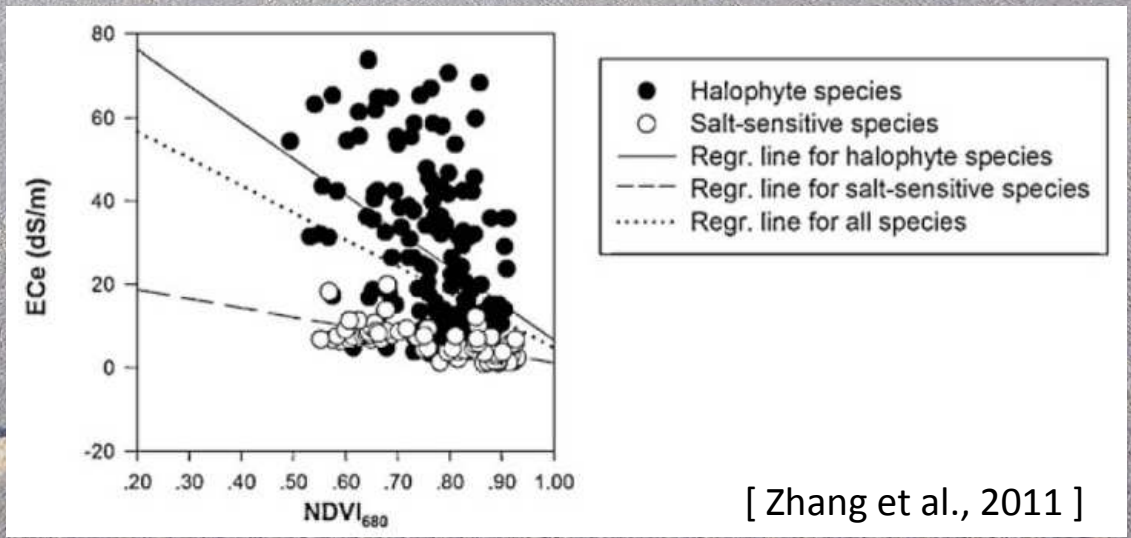


Remote sensing of soil salinity based on the NDVI of crops



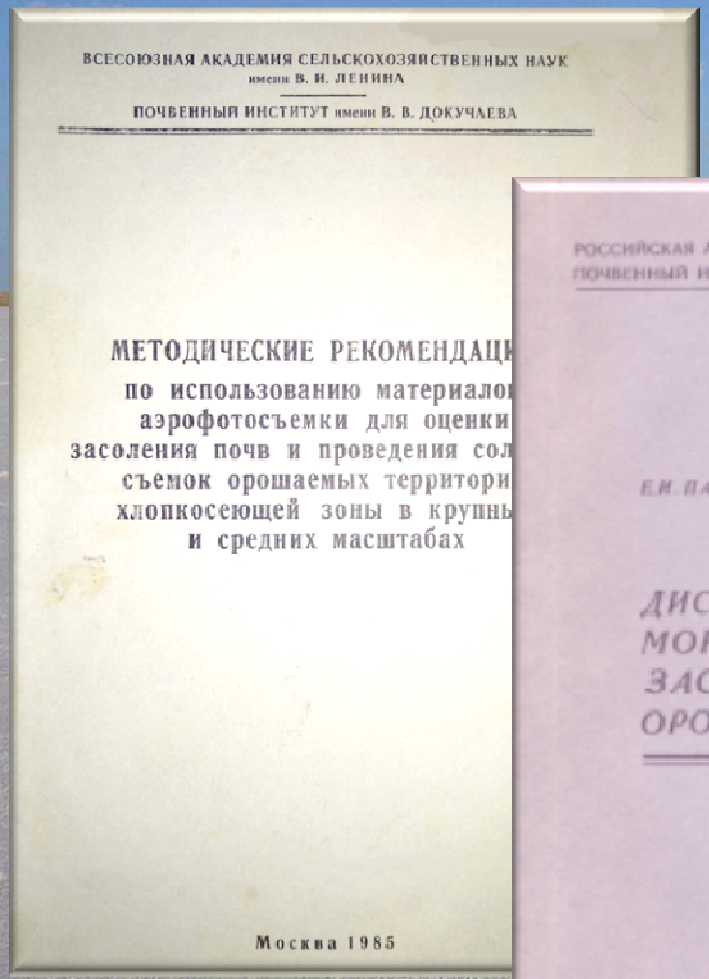
[Hamzeh S. et al. 2013]



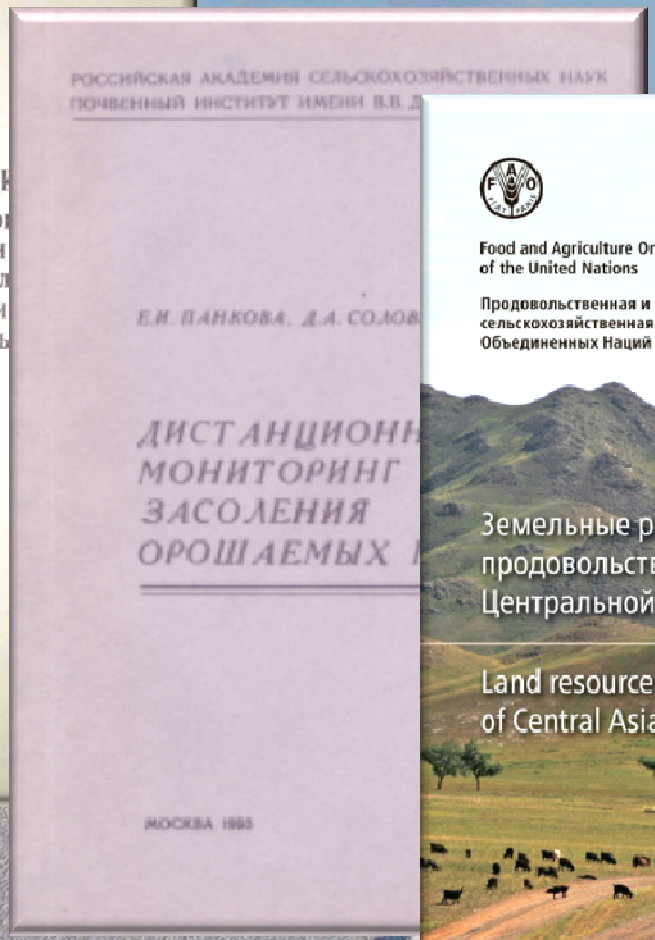


[Zhang et al., 2011]

The methodology already developed for monitoring soil salinity using remote sensing data



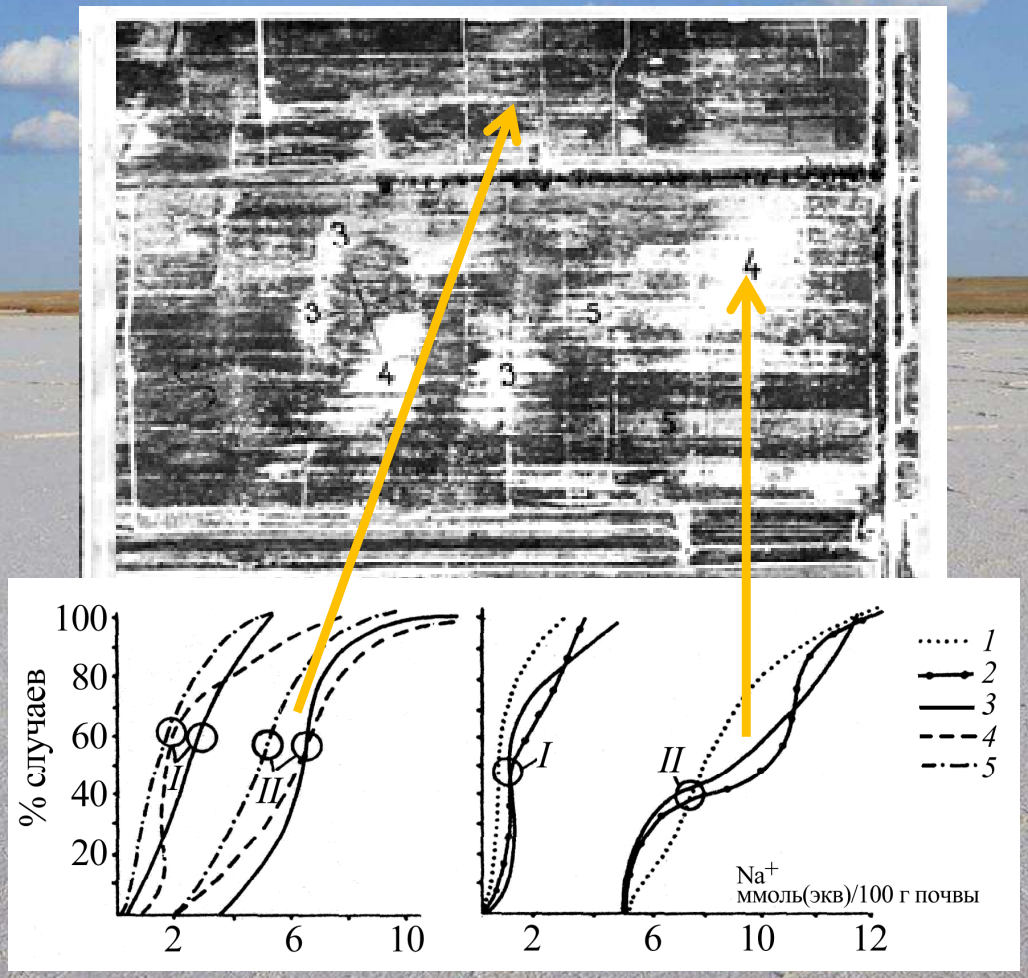
1985 г.



1993 г.

2016 г.

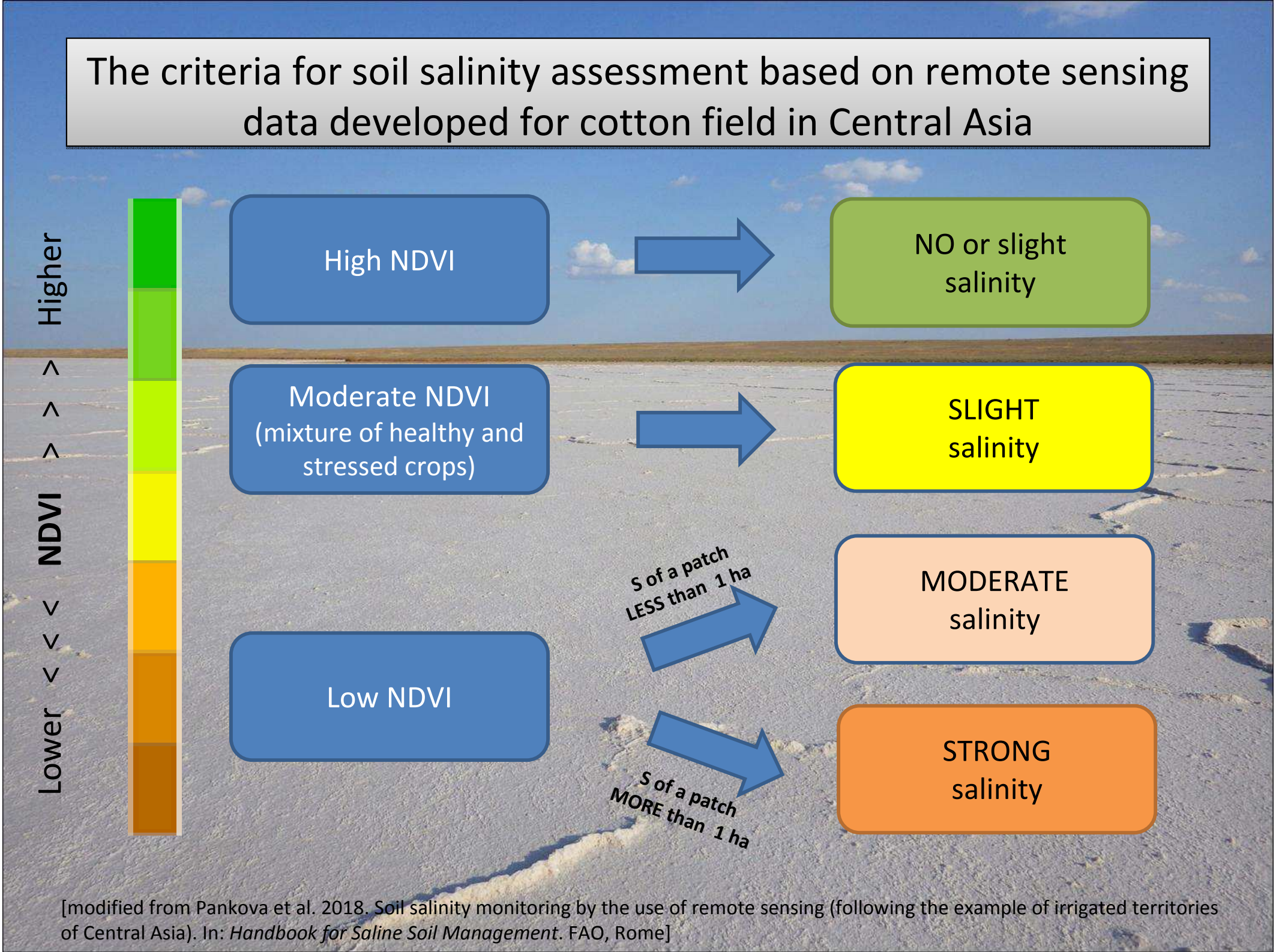
The detection of soil salinity should be based on the computer-based analysis of the pattern of crop failures



I – dark components of imagery; II – light components of imagery.
Soil layer, cm: 1 – 0-25; 2 – 0-50; 3 – 0-100; 4 – 100-200; 5 – 200-300

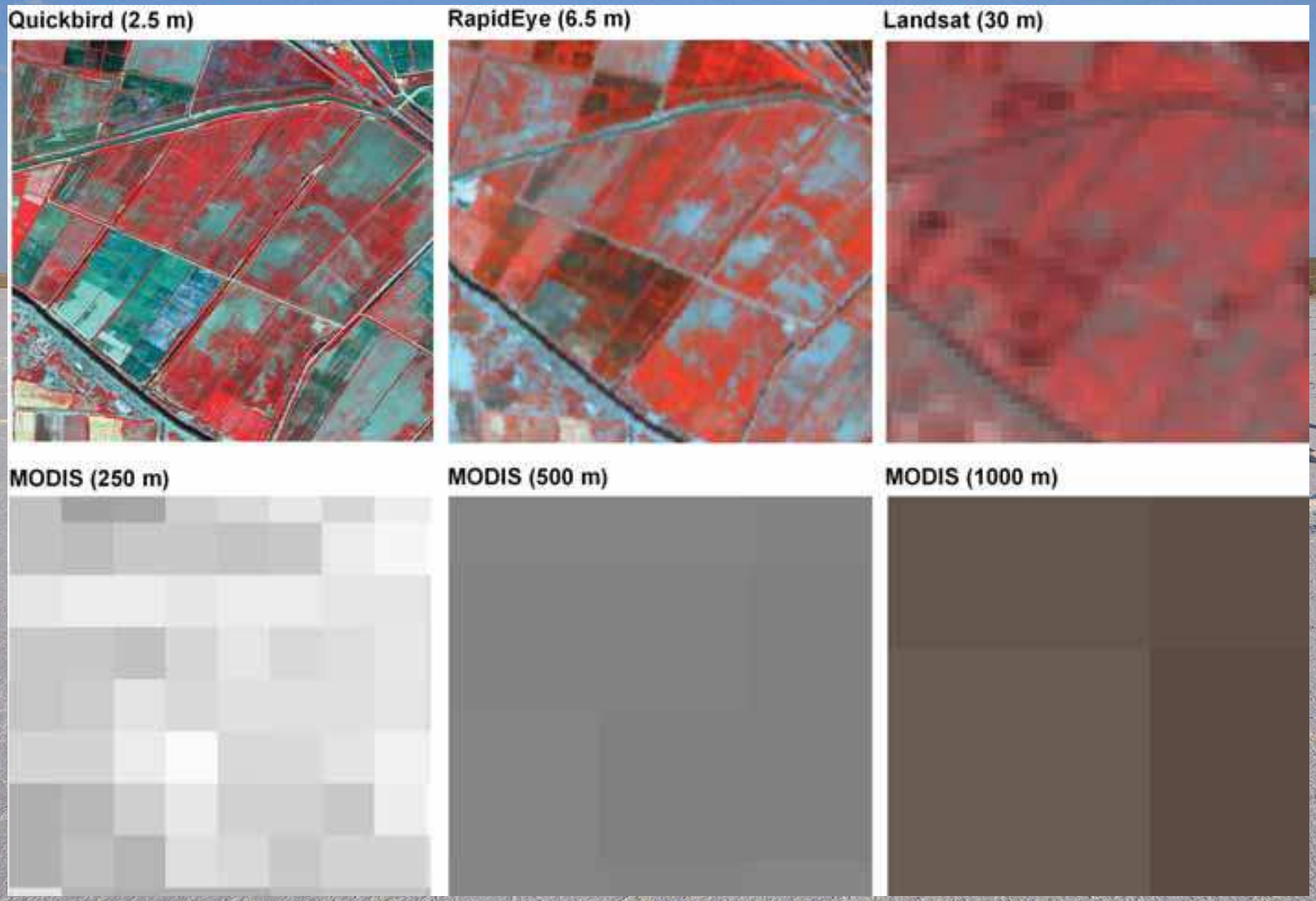
[Pankova Ye.I., Soloviev D.A. Remote monitoring of soil salinity in irrigated lands. Moscow, 1993]

The criteria for soil salinity assessment based on remote sensing data developed for cotton field in Central Asia



[modified from Pankova et al. 2018. Soil salinity monitoring by the use of remote sensing (following the example of irrigated territories of Central Asia). In: *Handbook for Saline Soil Management*. FAO, Rome]

The view of saline patches depending on spatial resolution of the imagery



[Fritsch V.S. 2013. Spatial and temporal patterns of crop yields and marginal land in the Aral Sea Basin : derivation by combining multi-scale and multi-temporal remote sensing data with a light use efficiency model. Dissertation .

Data

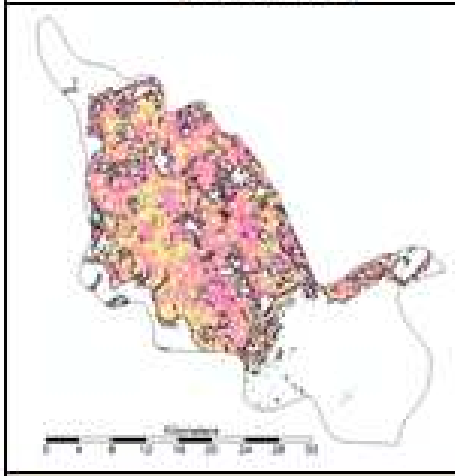
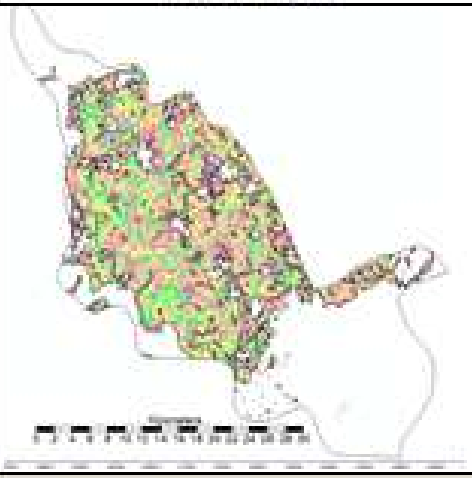
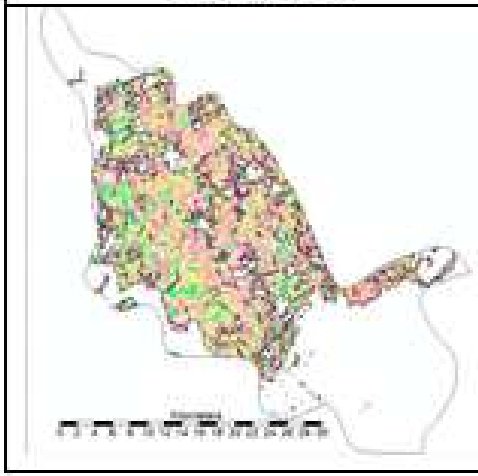
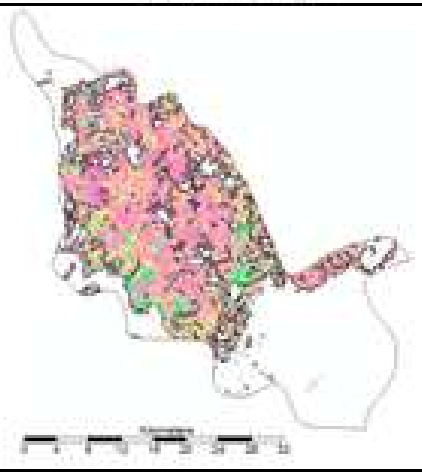
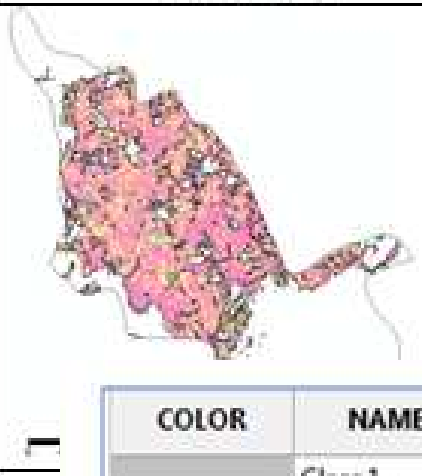
- Croplands – **LPDAAC GSFAD**
- MODIS NDVI (**MOD13Q1**) for 2000-2018 (second half of September)
- **Landsat 5 TM NDVI** for 2000, 2001, 2006, 2007, 2008, 2010 (second half of September)

Study area

Nukus district of Karakalpakstan (Uzbekistan)

The goal of this study was to develop a procedure for operational assessment of soil salinity with the use of remote sensing data

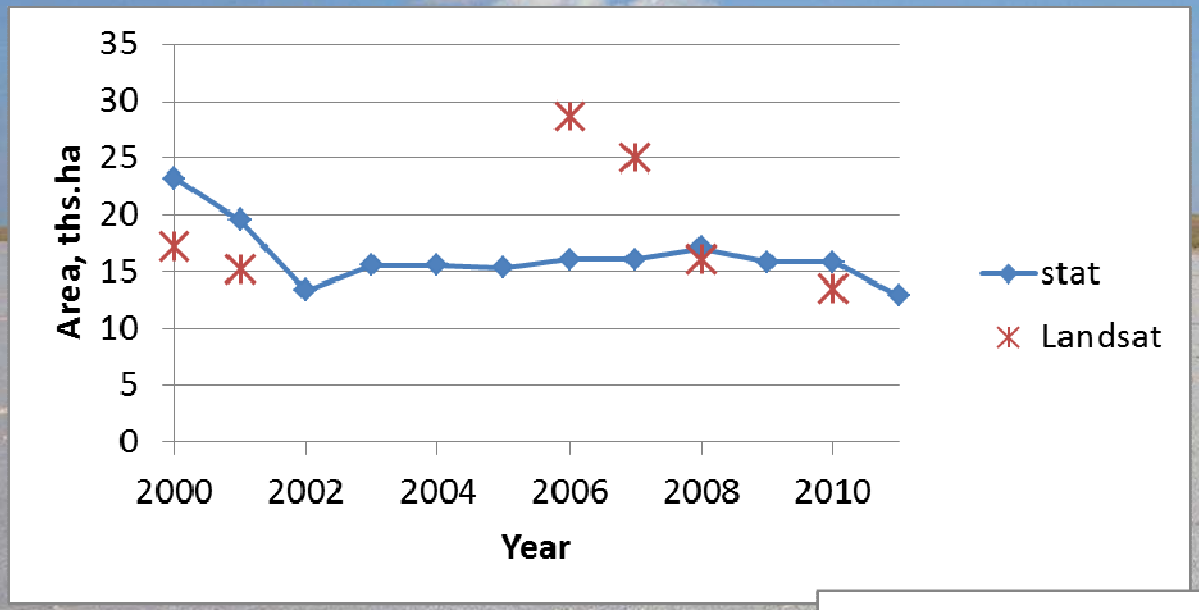
Salinity trends in Nukus district of Karakalpakstan according to Landsat data

16/09/2000	19/09/2001	17/09/2006
		
20/09/2007	**22/09/2008**	**28/09/2010**
		

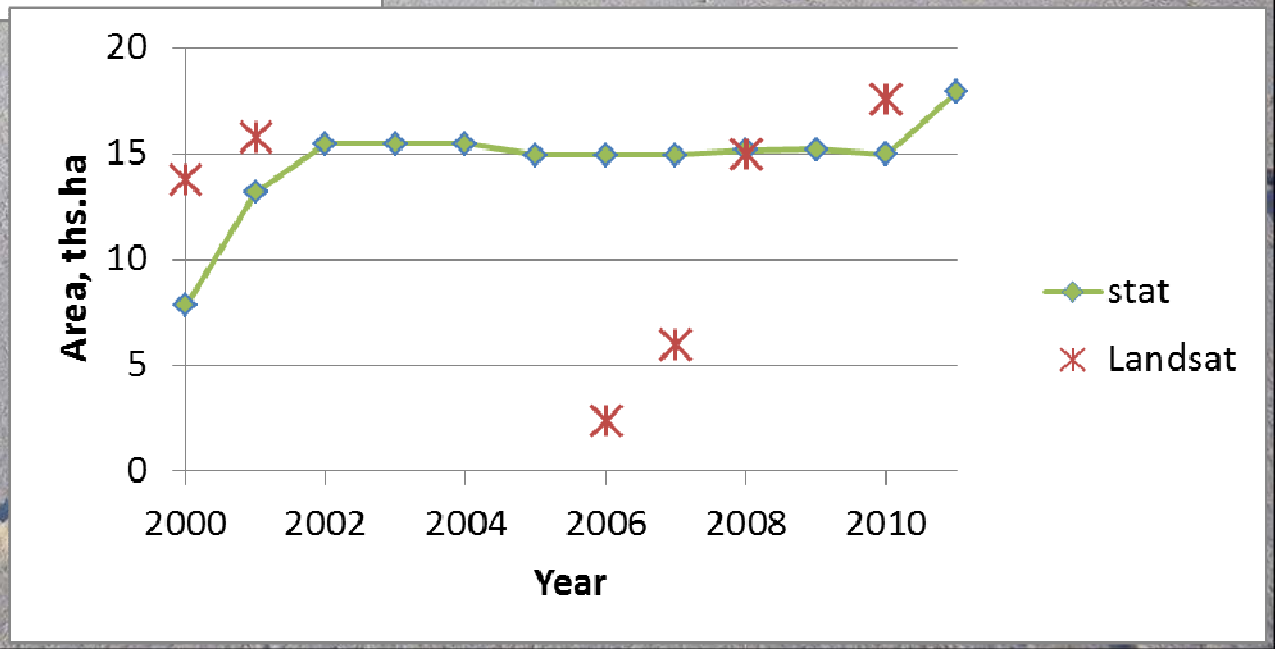
COLOR	NAME	DESCRIPTION
	Class 1	not cropped
	Class 2	strongly saline
	Class 3	slightly saline
	Class 4	nonsaline

Comparison of official data and Landsat interpretation data in Nukus district of Karakalpakstan

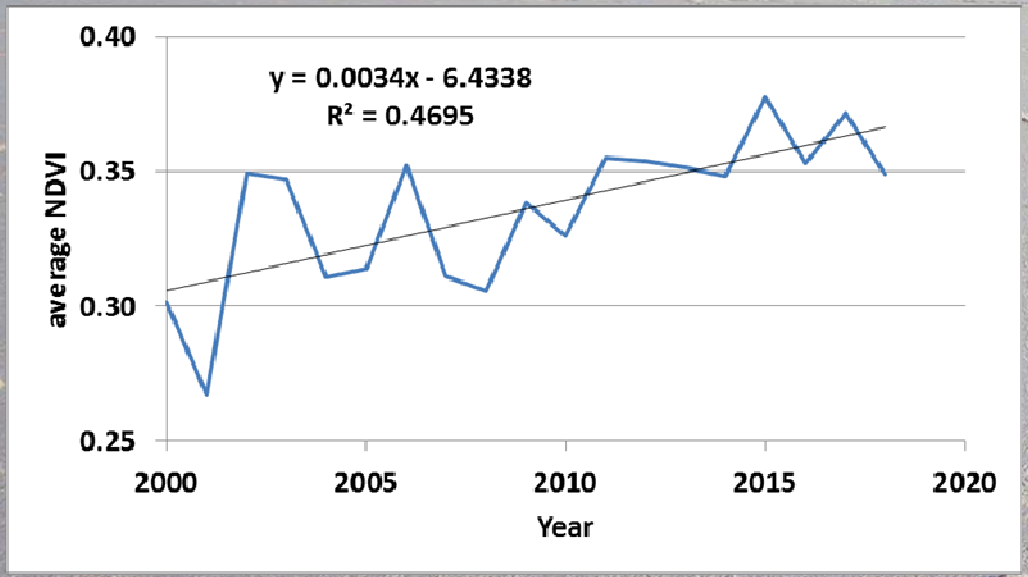
Nonsaline and slightly saline

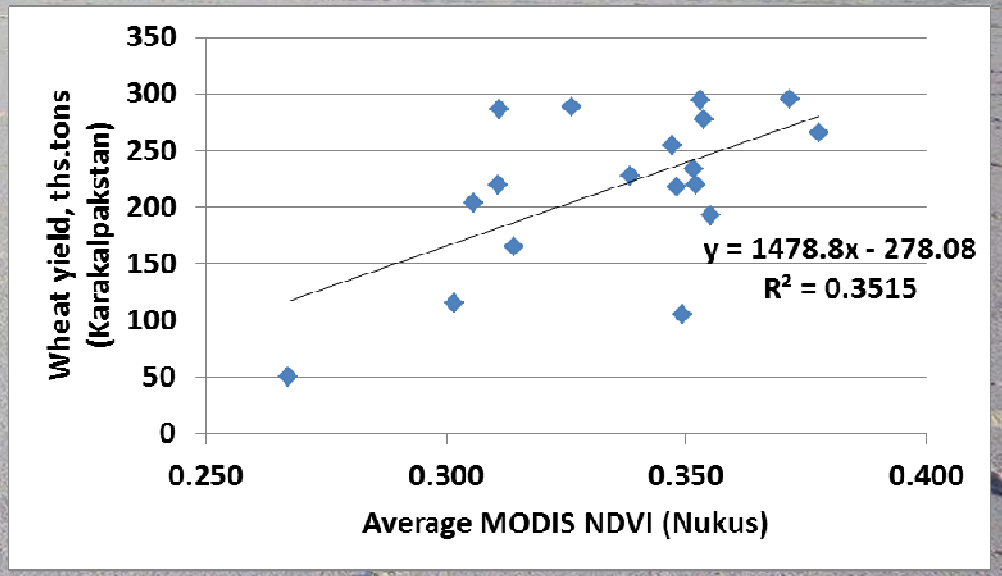


Strongly and moderately saline



Comparison of data on yields and MODIS NDVI in Nukus district of Karakalpakstan





Conclusions

•The analysis of remote sensing data show the pronounced dynamics in soil salinity of irrigated cropland of Nukus region

•The most optimal years (with enlarged areas of nonsaline and slightly saline soils) in Nukus district were 2006 and 2007; the most negative years (with enlarged areas of strongly and moderately saline soils) were 2000, 2001, 2008 and 2010 (out of six years studied)

•There was a good correlation (R^2=0.35) found between average NDVI data of MODIS with the crop yields (wheat)

• It is highly demanded that the national monitoring of soil salinity includes the analysis of remote sensing data for assessment and decision support in the process of soil and water management of irrigated croplands.


Thank you for attention!