
Photo: Dnaiel Hug

Geoinformation technology for increasing the sustainability of agricultural production and water security in the Aral Sea Basin

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Background and Motivation

Water security is an immensely important issue in the Aral Sea Basin

→ Supply of water, food and energy is endangered and the environment is threatened

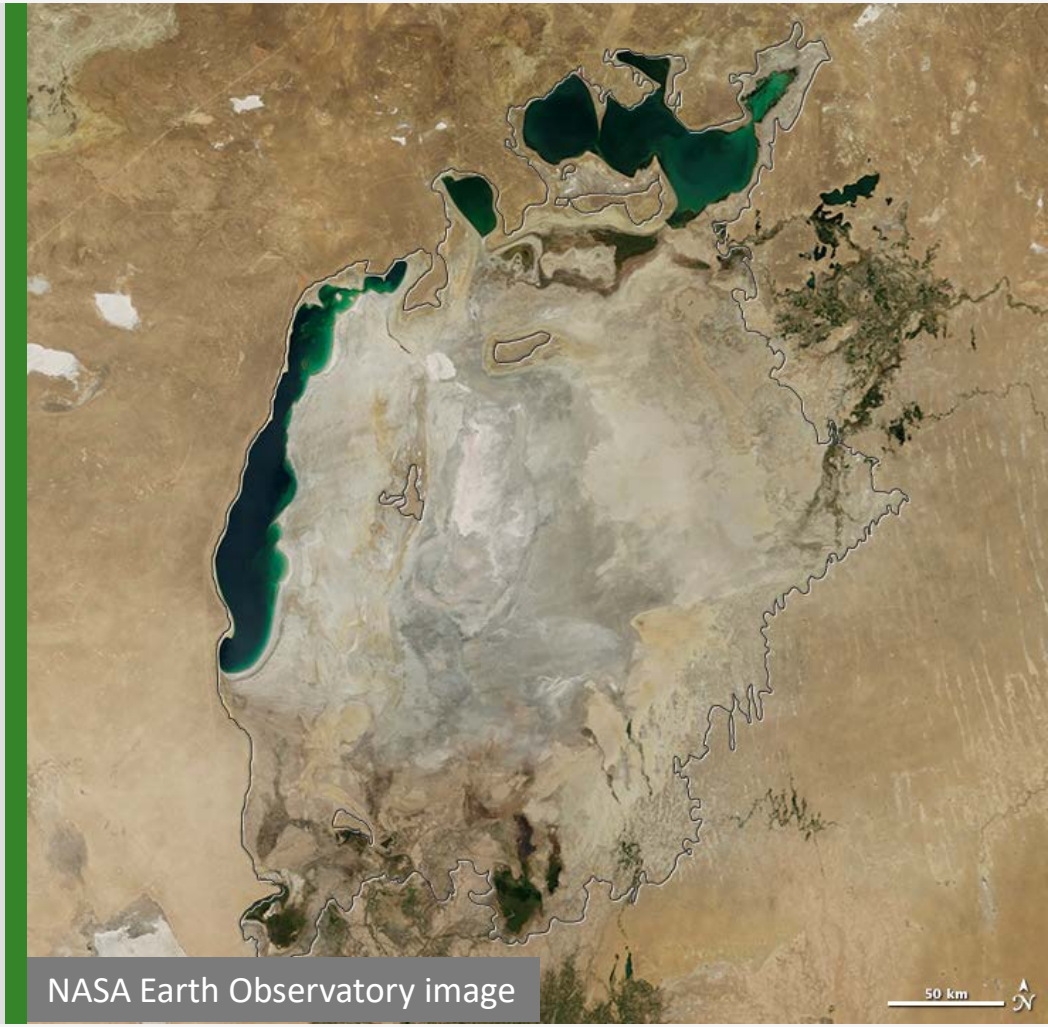
→ Use of digitization is urgently needed

Challenges of Developing Countries (Sheffield et al. 2018):

→ Databases and tools for informed decisions in agriculture are absent

→ Institutional weaknesses throughout all levels

→ Cross-sectoral thinking is underdeveloped

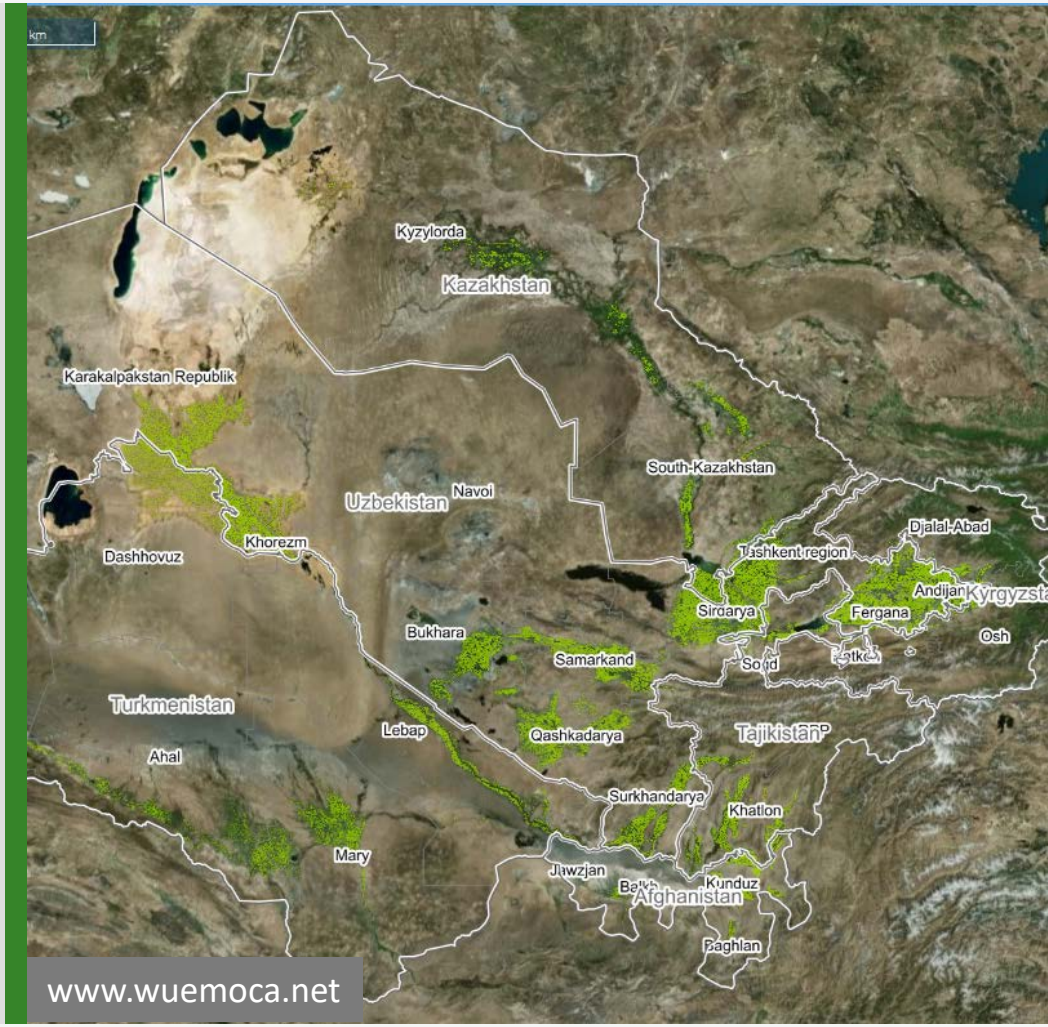


Objectives

→ To review the potential of remote sensing (RS) and geoinformation sciences for gathering relevant information in the land and water sectors in the Aral Sea Basin

Because RS-based results remain unlinked from regional knowledge and information platforms:

→ To outline requirements and challenges to better bring knowledge and data from RS into practice



Review Methods & Metrics

→ Literature search using Web of Science and Scopus databases from 2008 to 2019

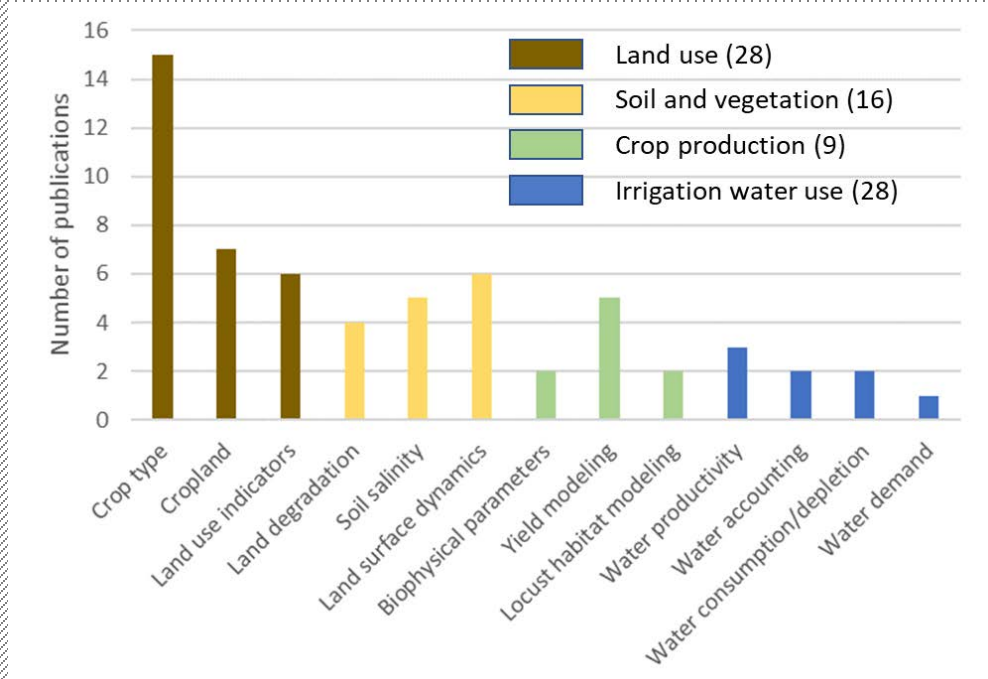
→ Search terms

(i) remote sensing (RS), (ii) countries in the ASB, and

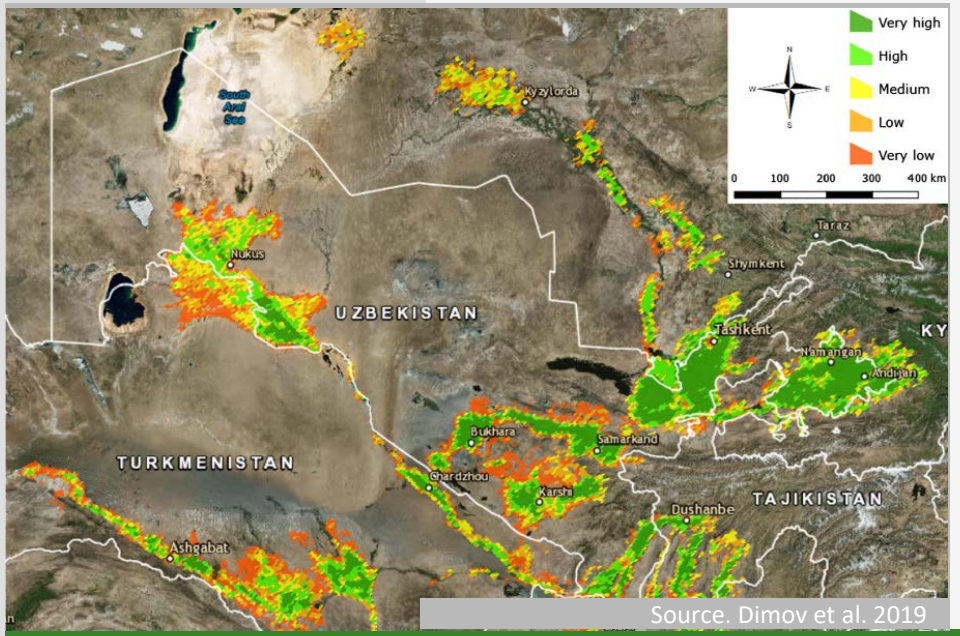
(iii) keywords referring to irrigated land use system analysis (including land use, soil and vegetation, crop production, and irrigation water use)

→ Exclusion of duplicates and studies with a spatial focus outside the Aral Sea Basin

⇒ 49 international, peer-reviewed scientific studies were further grouped according to publication year, scale, research topic



Methodological focus of the 49 analysed studies

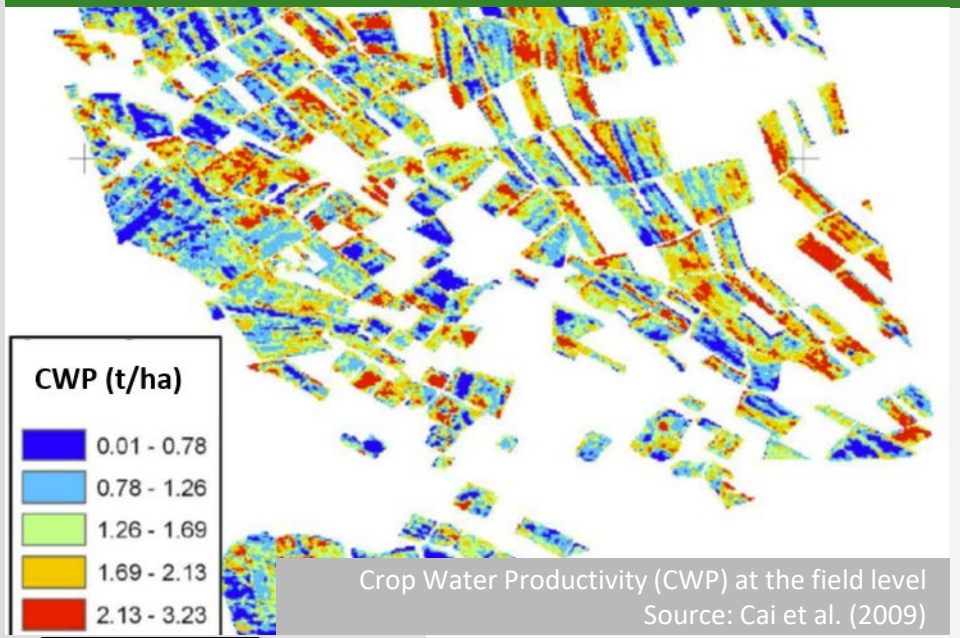


Source. Dimov et al. 2019

Regional Scale Assessments

are based on MODIS time series
and high resolution data such as Landsat, e.g.:

- Dimov et al. (2019): Agricultural Performance Index
- Löw et al. (2018): Hot spots of land abandonment
- Conrad et al. (2016): Land use intensity



Crop Water Productivity (CWP) at the field level
Source: Cai et al. (2009)

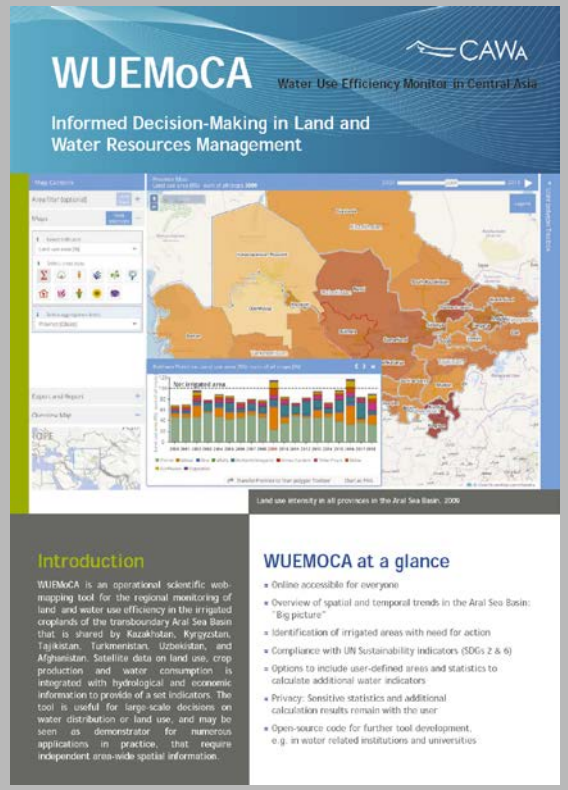
Farm scale and province level assessments

use high resolution data such as Landsat or RapidEye, e.g.

- Cai et al. (2009): Immense crop water productivity (Syr Darya Province, Uzbekistan)
- Thevs et al. (2015): Water consumption levels of crops (Lebab Province, Turkmenistan)
- Dubovyk et al. (2013): Drivers of vegetation decline (Khorezm, Uzbekistan)

Water Use Efficiency Monitor for Central Asia WUEMoCA

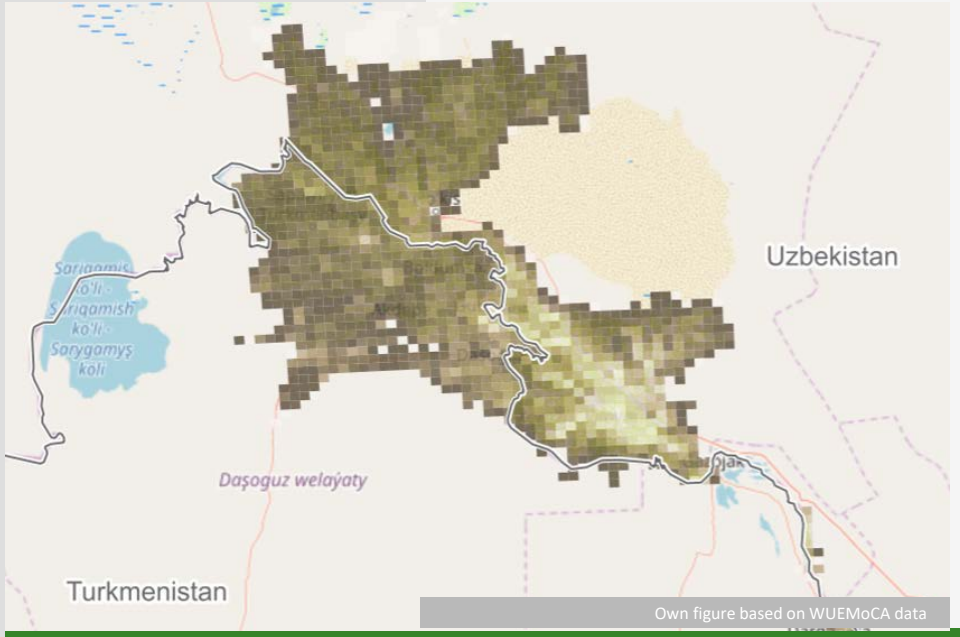
- → **German Water Initiative in Central Asia** 2009-2019 (*https://www.cawa-project.net/*)
- → **Decision-support tool** for identifying areas with need for action.
- → **Source of new data**: Integrates satellite RS technology (MODIS), i.e. for land use mapping crop yield estimations and evapotranspiration modelling
- → **Database** for administrative boundaries, water distribution units, regular grid cells and user zones
- → **Calculation tools for user data**
- → **Indicator groups:** land use, productivity and water use efficiency



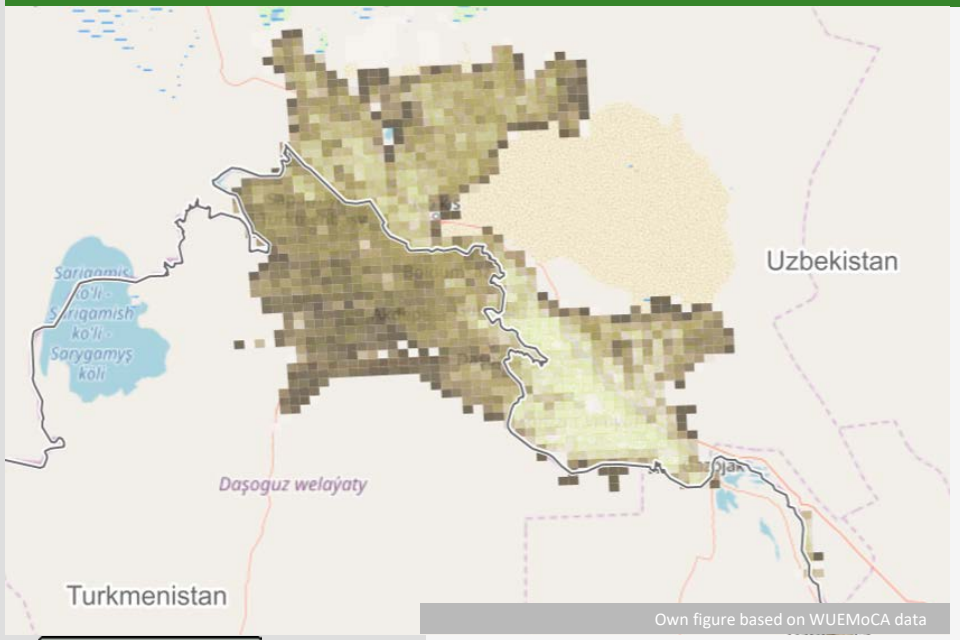
www.wuemoca.net

Conrad et al. 2019

Use case 1: **Detect unused (fallow) land**



Own figure based on WUEMoCA data



Own figure based on WUEMoCA data

WUEMoCA allows to detect and analyze parts of the cropland in the large-scale irrigation systems of the Aral Sea Basin that is unused within one cropping year (fallow).

Indicators: Temporarily unused irrigated land, fallow land frequency

Purpose: Increase Water Use Efficiency by decisions on the use of unproductive land: plant alternative, less water consuming crops (e.g. agroforestry), abandon, invest in irrigation and drainage infrastructure

The Figures show the **Amu Darya Delta**. Dark and bright cells in raster refer to mainly unused and heavily irrigated areas, respectively.

Top: Drought year 2008

Down: Water rich year 2010

Raster: 5 km cell size

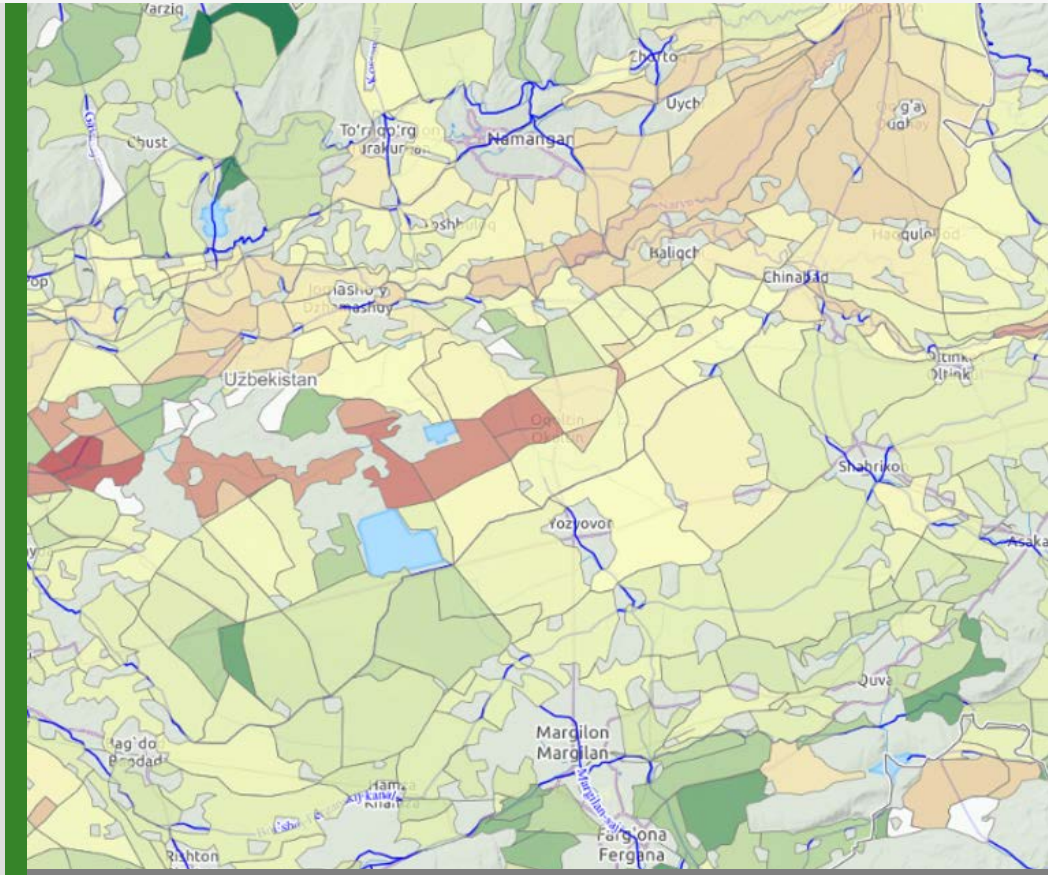
Use case 2: **Analyse Water Productivity**

→ **Indicator:** water productivity, defined as crop-specific harvest in kg/m³ of water consumed (measured in actual evapotranspiration).

→ **Purpose:** Water managers can assess the success of crop production for their channel command areas, i.e. the result of water supply from different sources including groundwater and precipitation.

Suitable for the elaboration of water saving options

can be translated into a contribution to the indicator „Change in water-use efficiency over time" in the UN Sustainable Development Goal 6.



Red = low water productivity
Green = high water productivity ("more crop per drop") and higher sustainability of crop production

Challenges for the development of WUEMoCA

Technical level

→ Limitations of remote sensing

→ Challenge of data integration

→ Lack of in situ data

→ Data availability and data sensitivity

Development level

→ User integration

→ Interdisciplinarity of the topic

→ Different views on science

→ International cooperation

→ Institutional structures in Central Asia

Utilization level

→ Ownership question (acceptance and usage)

→ Digital infrastructure in Central Asia

→ Expectations towards the information system

→ Data sensitivity

→ Political awareness of opportunities

Maintenance level and sustainability

→ Security of technical operation

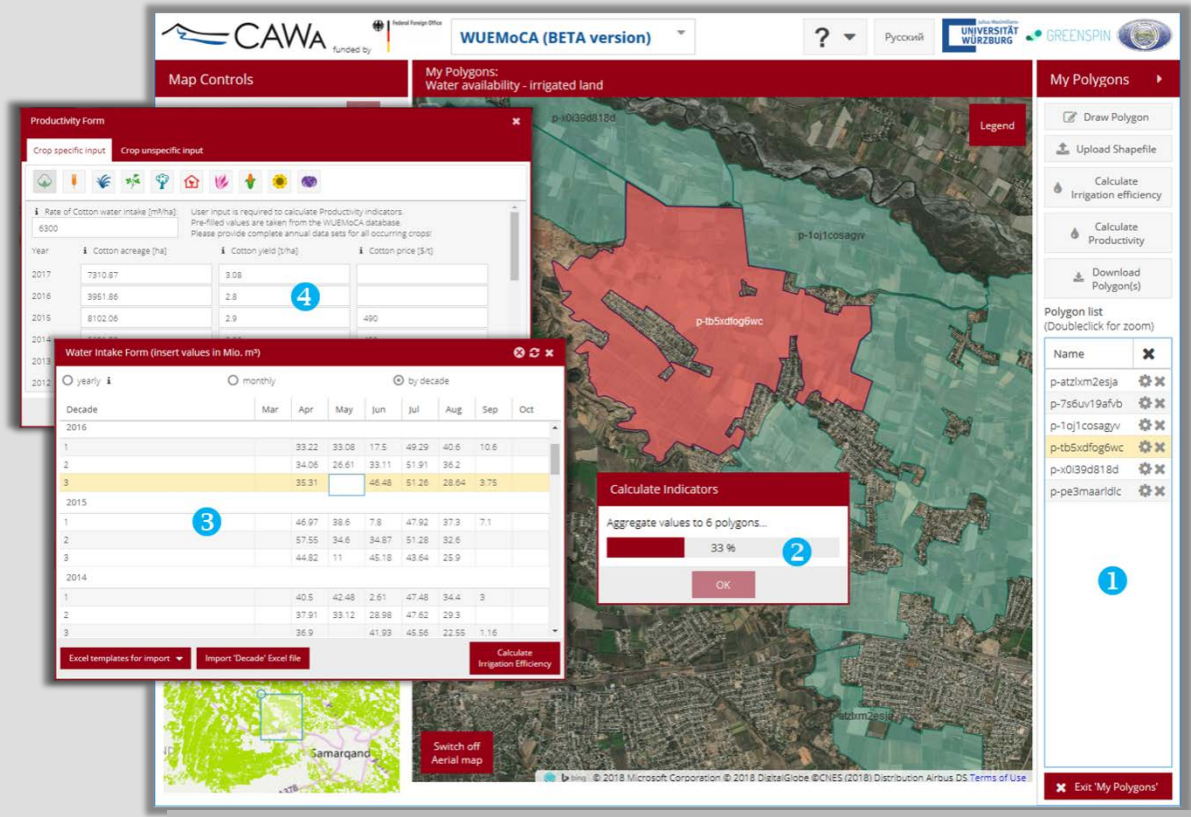
→ Access to cooperation

→ Current funding system: „Only projects“

→ Further extend WUoMOCA functionalities

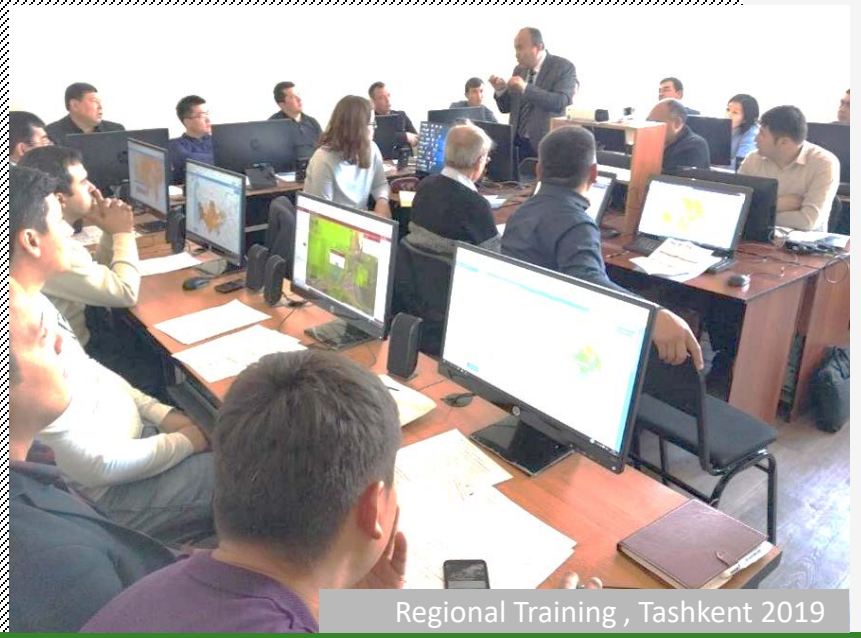
Increase „Ownership“
User Polygon Toolbox

- → Analyze own areas of interest
- → Fill data gaps with additional statistics (needed for increased practical use)
- → Analyze sensitive (water) data without sharing to the public (=> local database)
- → Monitor the irrigation performance within the ongoing season (=> more indicators)
- → Do further analyses on the basis of detailed temporal results



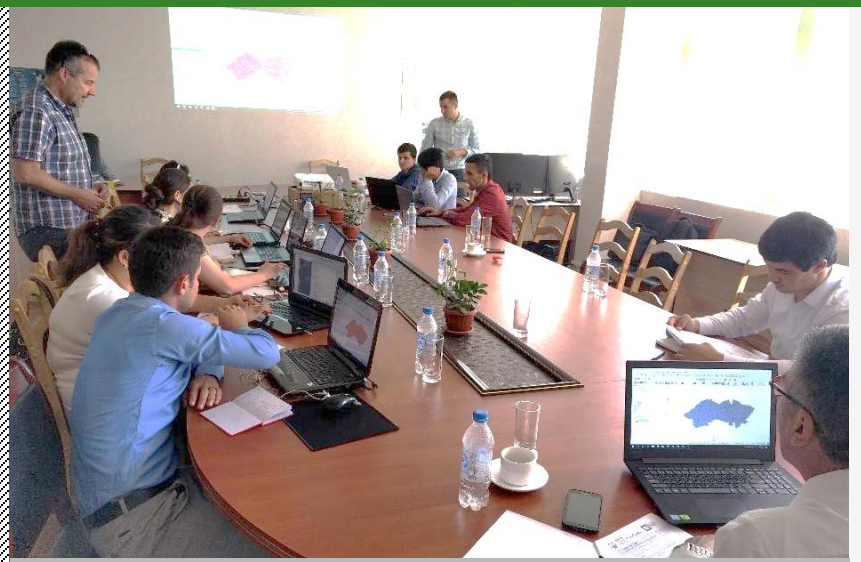
WUEMoCA User Polygon Toolbox
1 Polygon and Tool management panel
2 On-the-fly processing of all indicators
3 Irrigation efficiency calculation tool (with water intake from users)
4 Productivity calculation tool (with water intake, crop prices, statistical harvest etc.)

User Forum, Tashkent 2019



Regional Training , Tashkent 2019

Administrator workshop, Tashkent



CAWa-Edu-Seminar in the Acedemy of Science, Duschanbe (Tajikistan), Juli 2019

Increase „Ownership“ User integration

User Forum in Tashkent 2015 and 2019

Regional Training 2019

Developer exchange, common programming

Standardized field campaigns and R routines for filling technical gaps

Photos: Lucia Morper-Busch

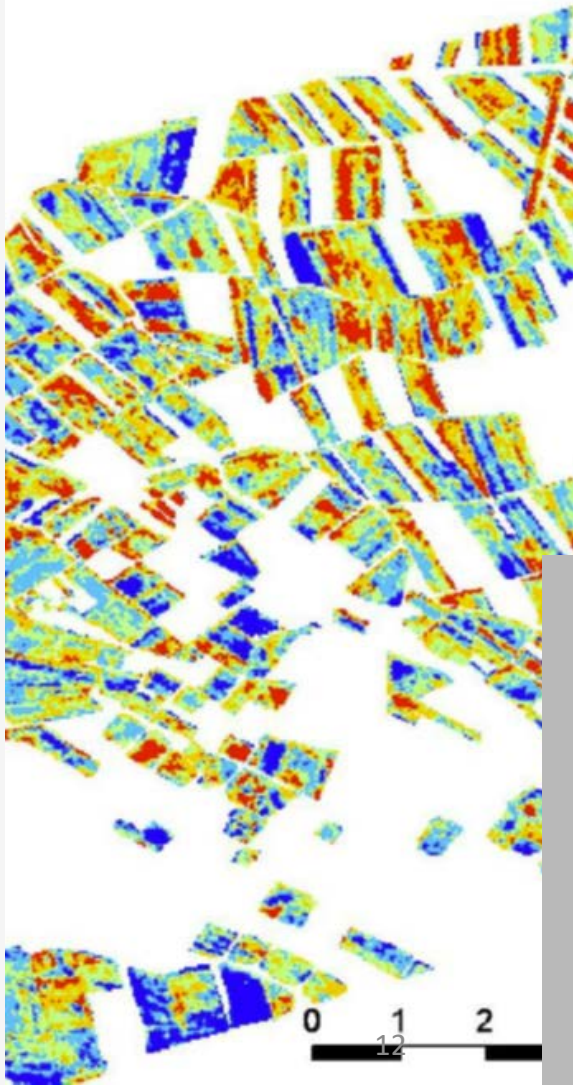
Conclusions

→ Increasing demand for a sustainable land and water management in the irrigation systems of the Aral Sea Basin

→ RS (products and methods) – an important source of multiple spatial information in the irrigation sector

→ Validation calls for linking field- and RS-based research and developing of accepted monitoring schemes

→ RS as a supplier of geoinformation to support databases towards the contribution to indicators systems (e.g., UN SDGs)



Conclusions

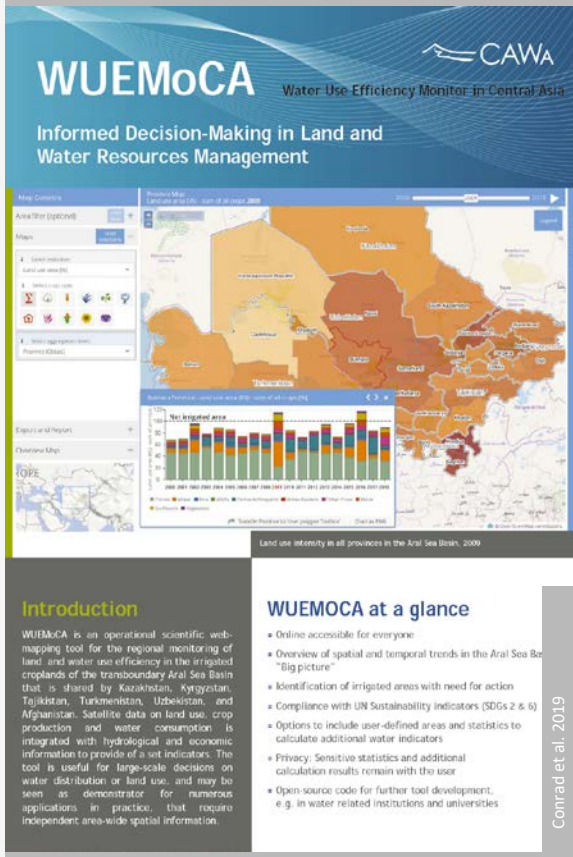
→ Online-databases and tools such as WUEMoCA can increase the acceptance of RS in practice, in particular when user interest are integrated from the initial steps

→ Maintenance and further funding of WUEMoCA after CAWa was explicitly requested from the Foreign Ministry of Uzbekistan

→ WUEMoCA cannot replace national tasks of monitoring and decision making

Utilize WUEMoCA as analysis and learning platform in practice and education

→ Strengthen the link to environmental science with social and political sciences to rise awareness and to improve through diversity of approaches



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References

- Cai, X., Thenkabail, P.S., Biradar, C.M., Platonov, A., Gumma, M., Dheerevath, V., Cohen, Y., Goldshleger, N., Ben-Dor, E., Alchanatis, V., Vithanage, J., Markandu, A., 2009. Water productivity mapping using remote sensing data of various resolutions to support 'More Crop per Drop'. Journal of Applied Remote Sensing 3(1): 033557.
- Conrad, C., Schönbrodt-Stitt, S., Löw, F., Sorokin, D., Paeth, H., 2016. Cropping intensity in the Aral Sea Basin and its dependency from the runoff formation 2000-2012. Remote Sensing 8(8): 1-26.
- Conrad, C., Morper-Busch, L., Netzband, M., Teucher, M., Schoenbrodt-Stitt, S., Schorcht, G., Dukhovny, V., 2019. WUEMoCA – Water Use Efficiency Monitor in Central Asia: Informed Decision-Making in Land and Water Resources Management. Information Brochure of the CAWa project. 10.25972/OPUS-19193
- Dimov, D., Löw, F., Uhl, J.H., Kenjabaev, S., Dubovyk, O., Ibrakhimov, M., Biradar, C.M., 2019. Framework for agricultural performance assessment based on MODIS multitemporal data. Journal of Applied Remote Sensing 13(02): 025501.
- Dubovyk, O., Menz, G., Conrad, C., Kan, E., Machwitz, M., Khamzina, A., 2013a. Spatio-temporal analyses of cropland degradation in the irrigated lowlands of Uzbekistan using remote-sensing and logistic regression modeling. Environmental Monitoring and Assessment 185(6): 4775-4790.
- Löw, F., Prishchepov, A.V., Waldner, F., Dubovyk, O., Akramkhanov, A., Biradar, C.M., Lamers, J.P.A, 2018. Mapping cropland abandonment in the Aral Sea Basin with MODIS time series. Remote Sensing 10(2): 159.
- Sheffield, J., Wood, E.F., Pan, M., Beck, H., Coccia, G., Serrat-Capdevila, A., Verbist, K., 2018. Satellite remote sensing for water resources management: Potential for supporting sustainable development in data-poor regions. Water Resources Research 54(12): 9724-9758.
- Thevs, N., Ovezmuradov, K., Vaziri Zanjani, L., Zerbe, S., 2015. Water consumption of agriculture and natural ecosystems at the Amu Darya in Lebap Province, Turkmenistan. Environmental Earth Sciences 73(2): 731-741.