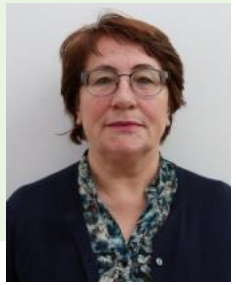
Kristina Toderich



Current position: Specially *Appointed Professor,* International Platform for Dryland Research and Education, Arid Land Research Center, Tottori University

Previous positions:

PhD, Associated Professor, Lead Scientist,
Regional Coordinator of International Centre for Biosaline Agriculture for Central Asia and Caucasus (ICBA-CAC) at the ICARDA sub-office in Tashkent, Uzbekistan;
Head, Faculty of Natural Sciences, Department of Desert Ecology and Water Resources Research, Samarkand State University , Samarkand , Uzbekistan

Email: ktoderich@alrc.tottori-u.ac.jp; toderichk@mail.com; k.toderich@cgiar.org

Tottori University
International Platform for
Dryland Research and Education

International Platform for Dryland Research and Education
IPDRE

Innovative climate resilient technologies and Approaches for Wate Use Efficiency and Circular Halophytic Mixed Farming Developmen in the Aral Sea Basin

Toderich K.N., Khujanazarov T.,Sultanova Zulfiya & Muratbek Ganiev

International Symposium on Ecological Restoration and Management of the Aral Sea

Virtual symposium

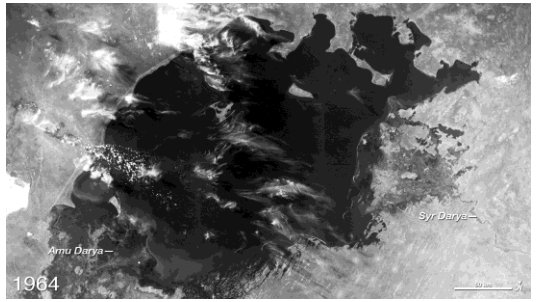
24 -25 November 2020

Shrinking Aral Sea and Salt Accumulation- has progressed at a rapid pace in the last 45-50

The large-scale irrigation infrastructure and complicated drainage systems using river water flowing into the Aral Sea have converted large territories of natural productive pastures and grasslands (Kazakh steppes) into irrigated farmlands. However, on the other hand, the amount of river water flowing into the Aral Sea has dropped dramatically due to intensive irrigation and monocultural cotton-wheat-based production systems. Due to river diversions the Sea water level in 1987-1989 fell enough to split it in two: the North Aral Sea and the South Aral.

Since 1985, the cycles of drought has been prolonged in the Aral Sea region, and almost no water has flowed into the lake from the two major rivers. Because of climate change, summers have become warmer, winter's cooler, spring frosts later, and fall frosts earlier. The growing season of the plant becomes shorter and the humidity tends to decrease.

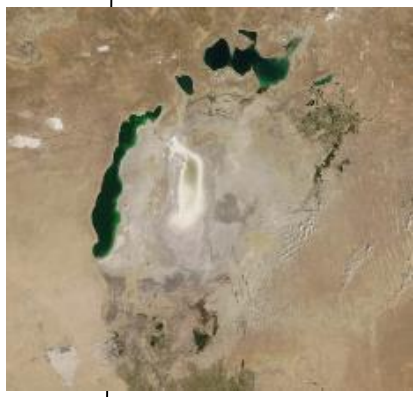
Water levels fluctuated annually between 2001 and 2017 in alternately dry and wet years. Between 2001 and 2017, water levels in the Aral Sea fluctuated annually with the occurrence of dry and wet years. Further irrigation water use and drought drove the eastern part of the Aral Sea completely dry in 2014 for the first time in 600 years.



1964

1989

2001



2009

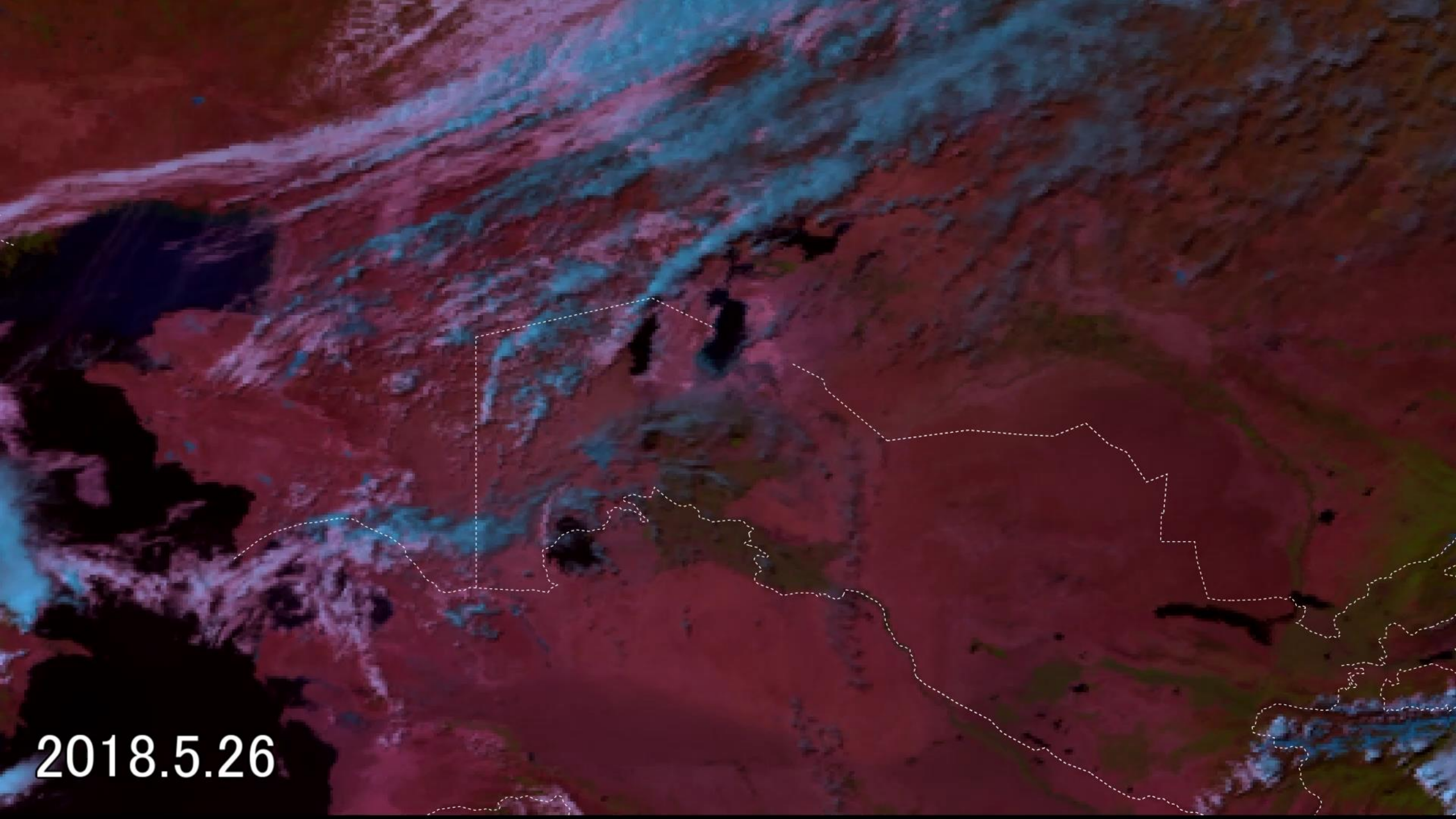
2014

2018

Workers of Kamystybas fish nursery reintroduced and multiplied species of fish (Northern Small Aral Sea, Kazakhstan,2018)

Series of images from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite documents the changes. In 1964 the Aral Sea was filled with water. In 1989, the water level dropped considerably. In 2001, the Aral Sea was divided into west and east, and the North Aral Sea (sometimes called the Small Aral Sea from the Kazakh side) was completely separated from the South Aral Sea. The salinity of water has risen as the Aral Sea has shrunk, and around 2001 the salinity was almost three times that of the 1960s.

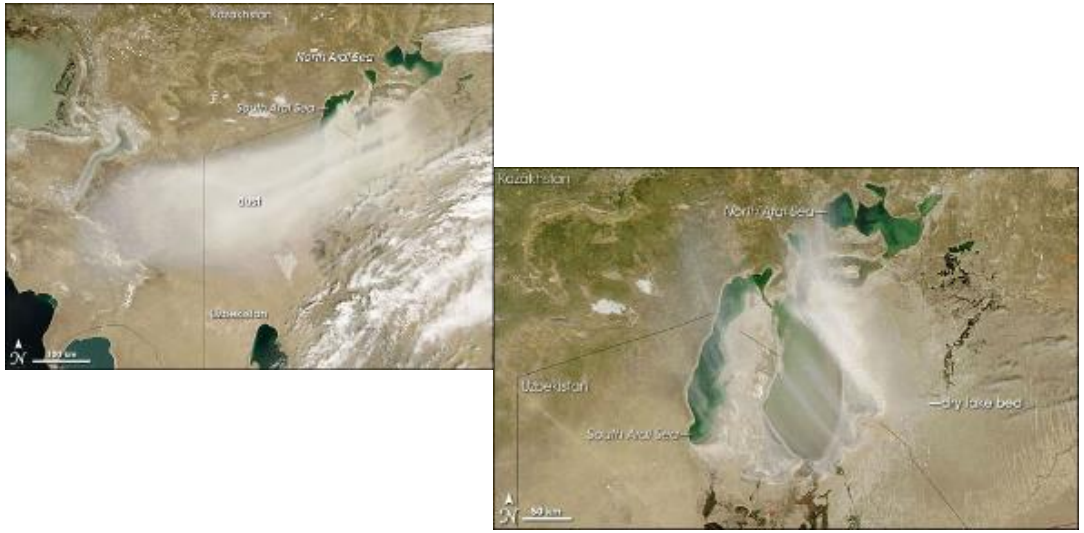
The Aral Sea has lost more than 90% of its original size since the 1960s. And the salinity of the water is about the same as the Dead Sea. In addition, increasingly salty water is contaminated with fertilizers and pesticides.


2018.5.26

Salts and Dust Storms

In the last few decades, the exposed dry bottom became the new “hotspot” of dust and salt storms. The Aral contained an estimated 10 billion metric tons of salt with sodium chloride (56%), magnesium sulfate (26%), and calcium sulfate (15%). Aerosols are carried by wind over 150,000 to 1500,000 km^2. The frequency of dust and sand/salts storms varies in a wide range 5-146 days/year. The salty dust blew off the lakebed and settled onto fields, degrading the soil. Croplands had to be flushed with larger and larger volumes of fresh river water. Toxic salts and dust storms dramatically are affecting health of animals and people there

Young boy believes in better live, Aralsk settlement , Kazakhstan



)

The salty dust storms originating from the dried-up lakebed of the Aral Sea (2018)

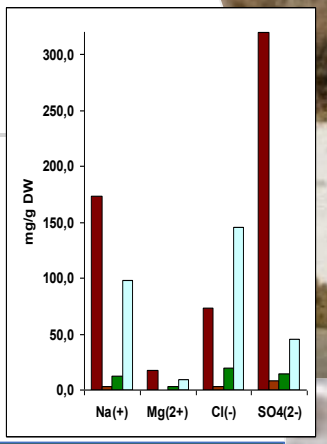
https://earthobservatory.nasa.gov/images/19853/dust-storm-over-the-aral-sea

Dust plumes from the old lake bottom on the east coast of the Aral Sea (November, 2017)

https://earthobservatory.nasa.gov/images/8182/dust-storm-aral-sea-kazakhstan

The key Issues:

- Water intensive pre-season leaching to ameliorate saline soils
- Non-optimized irrigation system & Alternative Use of Water Resources/Water Recycling
- Few livelihood opportunities
- Lack of knowledge
- Lack of markets



Priority: finding solution/options to manage root zone salt crusts (content of toxic salts - 18-58%)

Cotton fields

Furrow irrigation with extensive water discharges

Drainage channels: source of water loss

Ўзбекистон Республикаси
Инновацион ривожланиш
вазирлиги

Оролбўйи – экологик инновациялар ва технологиялар ҳудуди

Оролбўйи муаммосига бағишланган халқаро конференция

28 давлатнинг 250 дан ортиқ вакиллари иштирокида БМТ шафелигида юқори даражадаги “**Оролбўйи – экологик инновациялар ва технологиялар ҳудуди**” халқаро конференцияси ташкил этилди

“Оролбўйи – экологик инновациялар ва технологиялар ҳудуди” концепция лойиҳасини тасдиқлаш юзасидан БМТ махсус **резолюциясини қабул қилиш таклифи илгари сурилди**

“Оролбўйи – экологик инновациялар ва технологиялар ҳудуди” халқаро конференцияси якунларига оид ўзбек, рус ва инглиз тилларида **2100 нусхада инновацион китоб** нашрдан чиқарилди

Оролбўйи халқаро инновация маркази фаолиятини ривожлантириш Стратегияси

- Оролбўйи халқаро инновация марказини ривожлантириш **стратегиясини** ишлаб чиқиш
- Норматив ва ҳуқуқий ҳужжатлар тайёрлаш
- Оролбўйи ҳудудини ривожлантириш учун **инвестицияларни** жалб қилиш
- Оролбўйи халқаро инновация маркази фаолиятини **халқаро даражага** олиб чиқиш

2,758 млрд. сўм
(275 минг АҚШ доллари)

SATREPS - Япония

- SATREPS-2020 - давлат дастури бўлиб, Японияда **биринчи марта** Марказий Осиё бўйича лойиҳа қўллаб қувватланди
- Япония Фан ва технологиялар агентлиги (JST) томонидан танлаб олинган **10 та** халқаро лойиҳадан **энг яхши лойиҳа** деб топилди
- Ўзбекистон Республикаси иштирокидаги лойиҳа **биринчи марта** танлаб олинди, натижада Ўзбекистон **51-ўринда** дастур доирасида танлаб олинган давлатлар рўйхатига киритилди

Орол денгизи минтақасининг шўрланган ерларида Инновацион стартап лойиҳалар танлови

- Оролбўйи ҳудудида инновацион технологияларни **кенг жорий қилиш**
- Орол денгизи қуришининг **салбий оқибатларини** юмшатиш
- Инновацион амалий ишланмаларни **жорий қилиш**
-
- Стартап лойиҳалар танловига жами **37 та** лойиҳа келиб тушди
- **22 та** Стартап лойиҳа техник экспертизадан ўтказилди

1,003 млрд. сўм
(100 минг АҚШ доллари)

“Оролдаги боғим” агро-экотуризм лойиҳаси

- Инновацион ривожланиш вазирлиги томонидан молиялаштирилди
- Орол денгизи қуришининг салбий оқибатларини юмшатиш ва сайёҳлар сонини оширишга қаратилди
- Кўкаламзорлаштириш ишларида аҳоли иштирокини таъминлаш мақсадида **янги краудфандинг платформаси** (аҳоли молиялаштируви) яратилди
- **www.aralforest.org** веб-сайти ишга туширилди

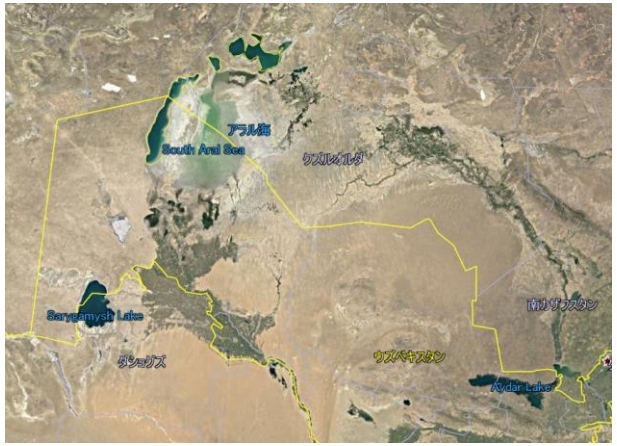
310 млн. сўм
(30,9 минг АҚШ доллари)

Circular Halophytic Mixed Farming (CHMF):

Large amount of irrigated land has faced

problems: soil degradation, deterioration in the quality of surface and groundwater, lack of sufficient water for irrigation, etc.

Crop reduction



Resettlement, unemployment, health issues

Halophytes - Drought and salt tolerant plants, can grow naturally on arid and saline fields or with 1-2 additional irrigation.

Non-Conventional Crops (NCC)

Bio-resources that are not used in traditional agriculture

Drainage water, artesian, underground, lake

（highly mineralized waters）

Unconventional water resources (NWR)

Tamarix

Can be used as feed and fuel, etc.

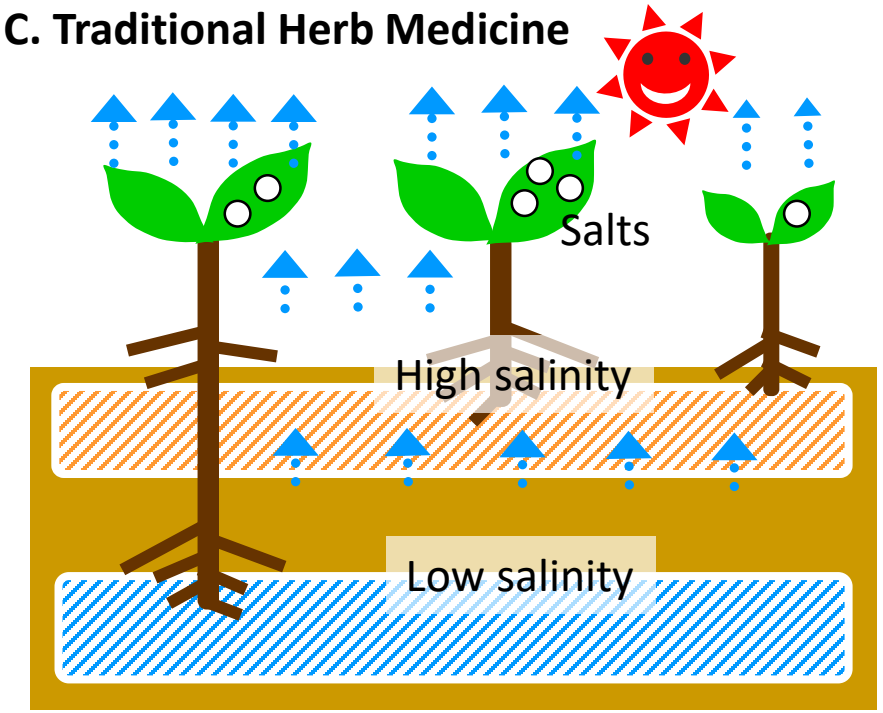
Task 1. Genetic Diversity and Screening salt- and drought- tolerant species for NCC candidates

A. Genetic Diversity of Halophytes & Non conventional Crops (genetic polymorphism; cellular mechanism of salt tolerance; reproduction strategy)

B. Screening ~10 candidates by isotopes analyses:

- $^{13}C/^{12}C$ in leaves: water use efficiency (≈ growth/ water uptake)
- $^{18}O/^{16}O$ in leaves: transpiration (=water uptake≈ salt uptake)
- $^{18}O/^{16}O$ in stem water: water uptake depth
- $^{15}N/^{14}N$ in roots: nitrogen source (N fixation or bio-available N in soil)

C. Traditional Herb Medicine

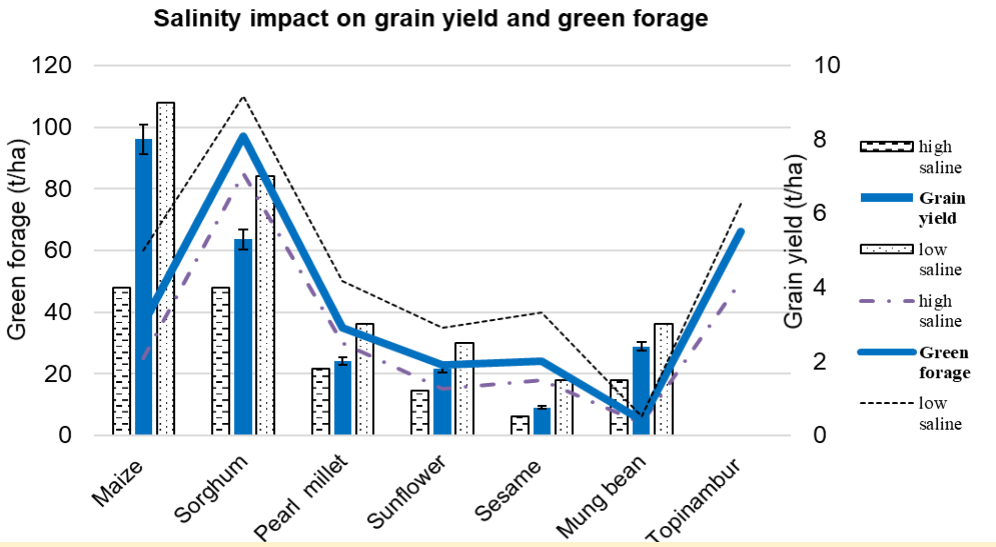


Target research High Saline Field Trial (Kazakhdarya village (about 50 km from former border line of Aral Sea)

Average threshold salinity level for examined crops ranged from 1,7-8.5 dS/m-1 ; the most sensitive to soils salinity in the field were shown for corn, some of legumes followed by sunflower, sesame, sorghum, fodder beet.

Pre-season leaching customarily used in the region to ameliorate saline soils should be re-considered; shallow groundwater table and the insufficient drainage make it the salt removal from the soil root zone ineffective, thereby negatively impacting agricultural productivity by as much as 30%.

- soil salinity of about 5,0-17,8 dS/m , ground water salinity of ~ EC 10-25 dS/m

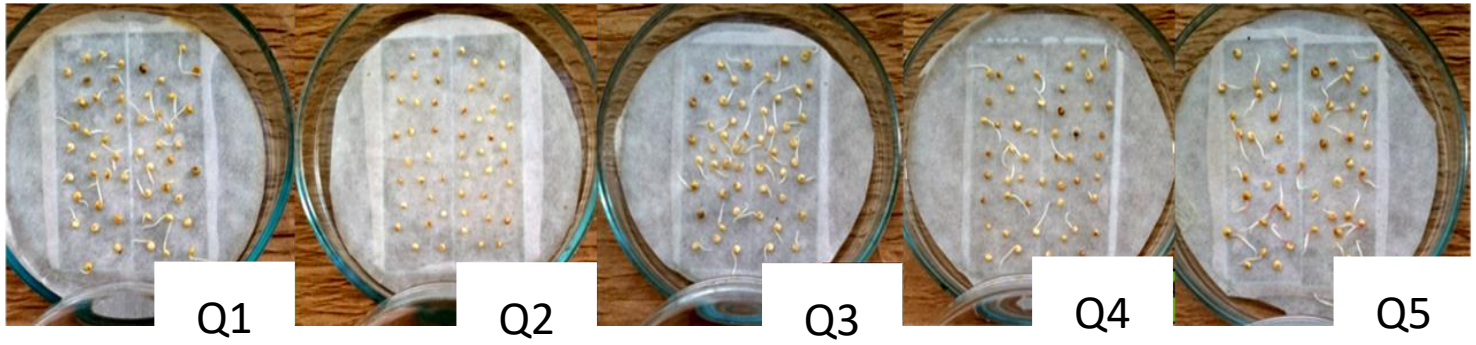


Mung bean Durdona variety grown in rice fallow nearly double yields and incomes of farmers,while making soils healthier, Karakalpakstan

The most sensitive to the soil salinity in the field were shown for legumes, followed by sunflower, sesame pearl millet. Maize and sorghum improved lines showed a significant increasing in green and dry biomass under moderate soil salinity

Nutritional and economic value of non-traditional crops

1. Measurement of nutritional value (content of proteins, lipids, carbohydrates, mineral and other useful substances), secondary metabolites, squalene, saponins, glycosides, etc.)
2. Evaluation of the impact of salinity on the non-traditional crops
3. Packaging technology for growing and production of non-traditional crops seeds
4. Socio-economic analysis, creation of the value chain for mixed cultivation (value assessment as feed, food, medicinal raw materials)



Quinoa seeds experimentally grown on the Shortanbai farm in Karakalpakstan

Opportunities: for " Zero_Waste Farming

Integrated Crops-Livestock multiprofile Use 'Agribisiness Model'

Saline groundwater

Desalinization unit

< 2,5 g/l

Biomass from halophytes &NCC production

Livestock feeding/dairy complex

Milk & Meat

- Centralized management
- Desalinized water permits production security
- Rural community planning
- Links to markets
- Investment in small and medium businesses

Grain production of sorghum and pearl millet nearby Panaev Farm

Ўзбекистон Республикаси Инновацион ривожланиш вазирлиги

Қорақалпоғистон Республикаси Қўнғирот туманида чорвачиликни ривожлантириш лойиҳаси

PANAEV FARMS

Фойдали ва табиий яшил гидропон омухта ем ишлаб чиқаришни йўлга қўйиш натижасида хўжаликнинг сут ва гўшт маҳсулдорлигини ошириш

Лойиҳа мақсади

Замонавий, юқори самарадорликка эга хусусий яшил гидропон омухта ем ишлаб чиқаришни йўлга қўйиш

Лойиҳа вазифаси

УМУМИЙ МАБЛАҒ
2,5 млрд. сўм

PANAEV FARMS маблағи
1 млрд. сўм

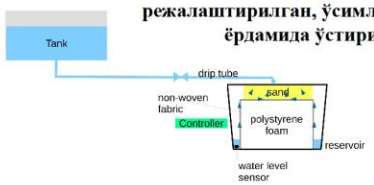
Инновацион ривожланиш вазирлиги маблағи
1,5 млрд сўм

Лойиҳа қиймати

Қум устида инновацион поника тизими (томчи)

SATREPS

"Sand Ponik"ни SATREPS билан биргаликда амалга ошириш режалаштирилган, ўсимликларни қумга инновацион усул ёрдамида ўстириш имкониятини беради



Режалаштирилмокда

2021 йил I чорак
10та талаба ва мутахассисларни малакасини ошириш мақсадида Исроил ва бошқа илмий стажировкага жўнатиш

Қорақалпоғистон Республикаси чорвачилик тармоғини ривожлантиришга қаратилган илмий-инновацион тадқиқотларни ташкил этиш

Қорақалпоғистон Республикаси фермер хўжаликларининг, шўр тупроқ ва сув танқислиги шароитида кунжут навларини етиштиришнинг ресурстежамкор агротехнологиясини яратишва амалиятга жорий этиш.

Лойиҳани жами харажати
(3 йилга мўлжалланган)
2,1 млрд. сум

Оролбўйи шароитида беданинг "Қорақалпақ-15" навининг навдорлигини яқшилаш, бирламчи уруғчилигини ташкил қилиш ва амалиятга жорий этиш

Лойиҳани жами харажати
(2 йилга мўлжалланган)
1,2 млрд. сум

КУТИЛАЁТГАН НАТИЖАЛАР

Сут, гўшт ва тухумнинг сифати яхшиланиб, 15% га миқдори ошади

Ҳайвонларнинг маҳсулдорлиги 15-20% га ошади

Қорамол иммунитети мустаҳкамланади ва касалликларга 50% га кам чалинади

Омухта ем етиштириш ҳаражатлари 40% га тежалади

Инновацион ривожланиш вазирлиги томонидан ветеринария ва чорвачиликни ривожлантириш йўналишида молиялаштирилган лойиҳаларнинг таҳлилий кўрсаткичлари

1 кг гидропон емнинг озукавий киймати таркиби

13% клетчатка
20,6% клетчатка
0,29мг селен
20,7% протеин
38,5 мг витамин Е
55,12 мг каротин

Ветеринария ва чорвачиликни ривожлантириш соҳасида умумий қиймати **5,5 млрд. сўмга** тенг **22 та** илмий лойиҳа молиялаштирилган
Шулардан:

750 млн. сўмлик
5 та инновацион лойиҳалар

4,75 млрд. сўмлик **17 та**
амалий лойиҳалар

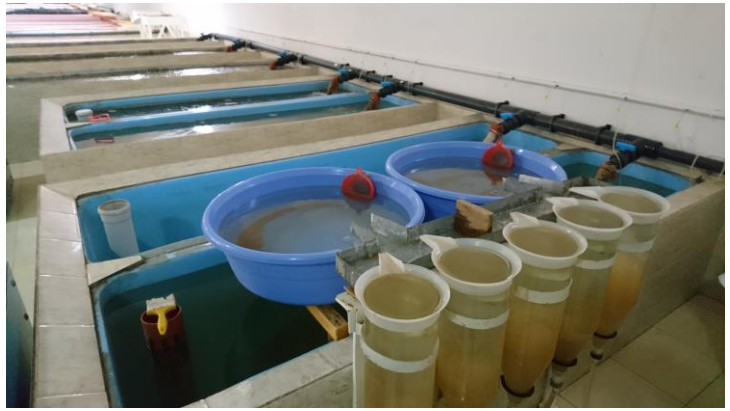
Closed Aquaculture BaliqNukus Farm ”- Agri-Bisiness Model No 2

- **Utilization of artesian hydrothermal saline water for aquaculture ;**
- **Artificial multiplication of high salt tolerant Aral Sea *Artemia* cyst as feed for fish;**
- **Studies of opportunity to use water after fisheries to generate community income ;**
- **Awareness and capacity building**

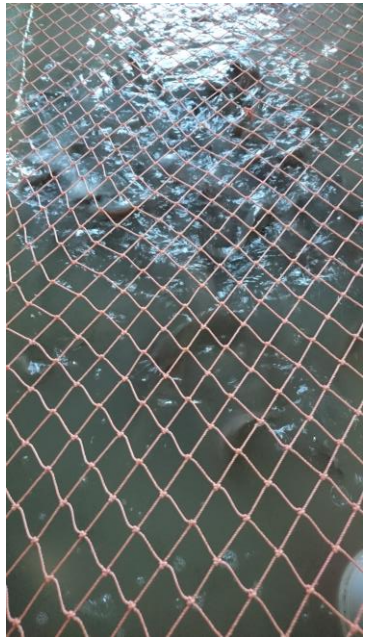
-

Water-recycling after fisheries to be used for ‘ kitchen garden and tree plantations)

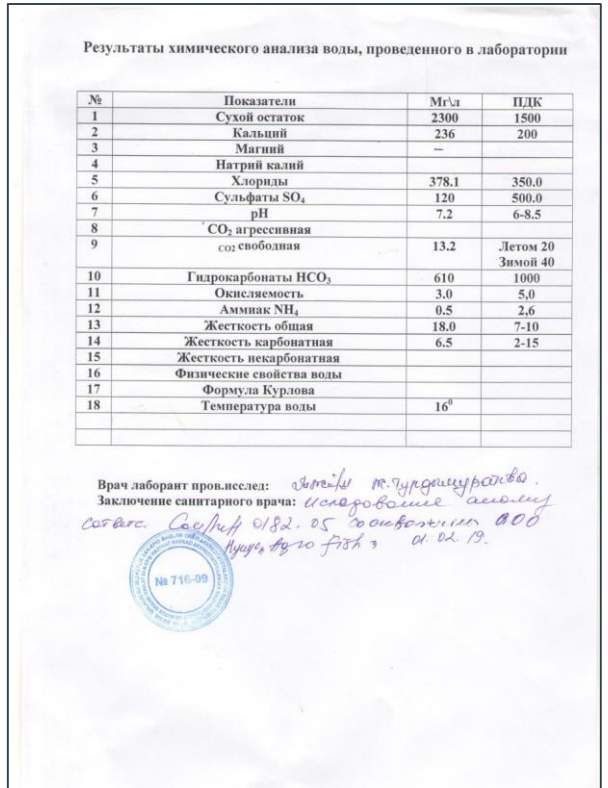
Artesian (hydrothermal) water used for aquaculture and forage production



Incubation of Artemia cyst



Adult catfish for local marketing



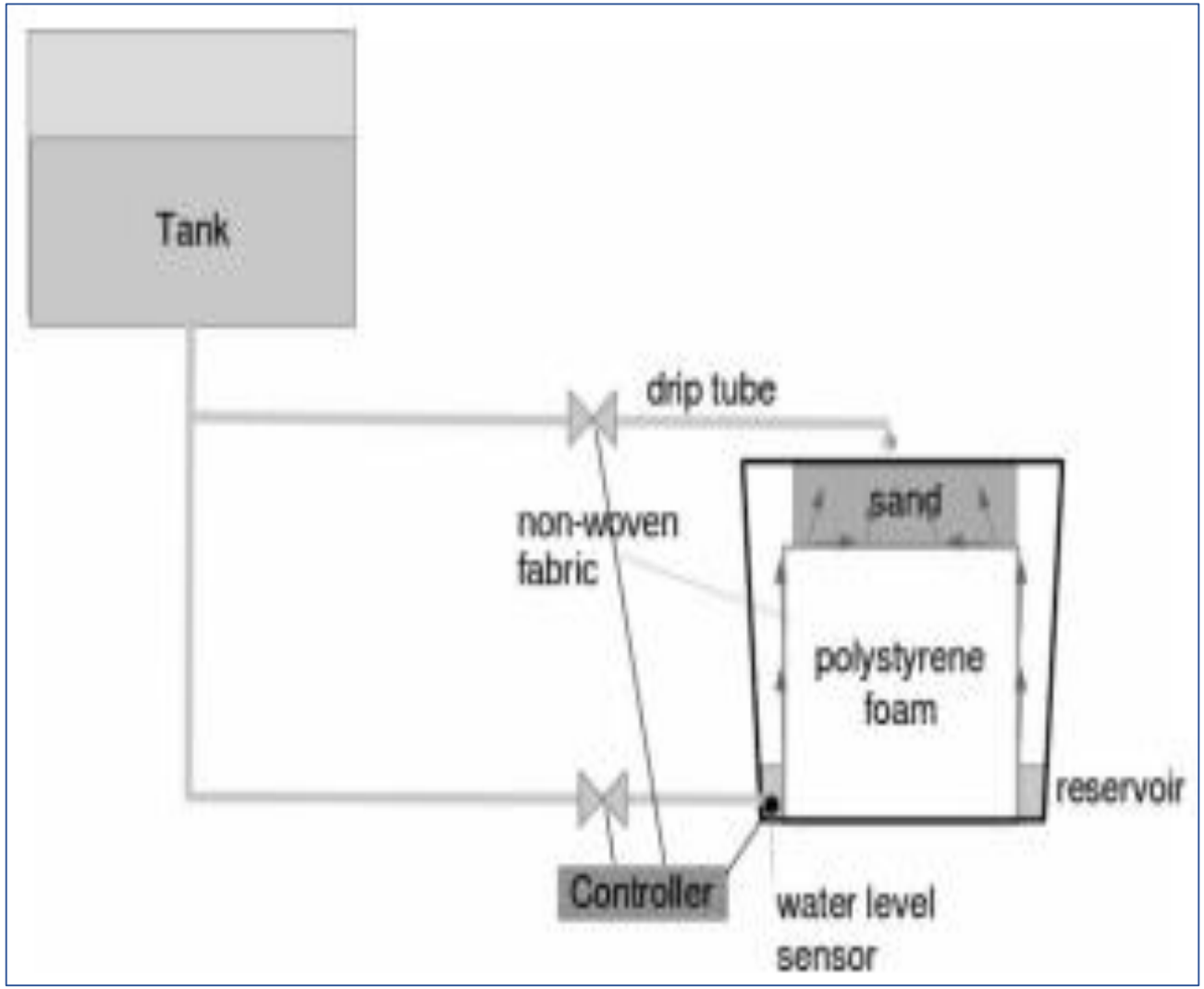
Результаты химического анализа воды, проведенного в лаборатории

№	Показатели	Мг\л	ПДК
1	Сухой остаток	2300	1500
2	Кальций	236	200
3	Магний	–	
4	Натрий калий		
5	Хлориды	378.1	350.0
6	Сульфаты SO_4	120	500.0
7	pH	7.2	6-8.5
8	CO_2 агрессивная		
9	CO_2 свободная	13.2	Летом 20 Зимой 40
10	Гидрокарбонаты HCO_3	610	1000
11	Окисляемость	3.0	5,0
12	Аммиак NH_4	0.5	2,6
13	Жесткость общая	18.0	7-10
14	Жесткость карбонатная	6.5	2-15
15	Жесткость некарбонатная		
16	Физические свойства воды		
17	Формула Курлова		
18	Температура воды	16^0	

Врач лаборант пров.иссled:
Заключение санитарного врача:

New Generation 'Sand Ponics' Technology

(no-soil Agriculture)



Design of New Sand Ponics System

Nutrition Value & Valorization of Halophytes Bio-Resources
(Hypothesis to be studied)

- **Salinity Impact on quality of grain NCC**
- **Nutritional Value (nutrients, secondary metabolites, squalene, saponins etc.)**
- **Technologies of Cultivation & Seed Production Packages**
- **Socio-economic and Value Chain of 10 best candidature for Halophytic Mixed Farming**

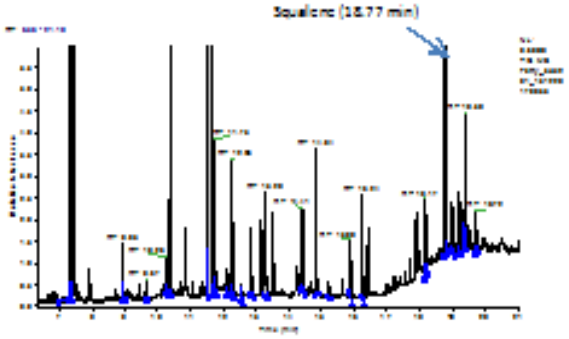


Figure 1: TIC chromatogram of FA-ME derived from Quinoa seed oil cultivar "Q_1". Identification of FA according reference MS library analysis. Inserted table (right) – RT, and the name of fatty acid methyl esters.

RT	Name of compounds
7.20	1,3-Benzenedicarboxylic acid, dimethyl ester
7.36	Methyl tetradecanoate
9.67	Tetradecanoic acid, 12-methyl-, methyl ester
10.26	9-Hexadecenoic acid, methyl ester, (Z)-
11.57	9-Octadecenoic acid, methyl ester, (E)-
11.75	Methyl stearate
12.13	cis-10-Nonadecenoic acid, methyl ester
12.26	
12.86	Hexadecanedioic acid, dimethyl ester
13.29	11-Eicosenoic acid, methyl ester
14.41	9,12-Octadecadienoyl chloride, (Z,Z)-
14.84	Methyl 3-cis,9-cis,12-cis-octadecatrienoate
15.21	Octadecanedioic acid, dimethyl ester
15.88	13-Docosenoic acid, methyl ester, (Z)-
16.24	Docosanoic acid, methyl ester
18.17	Tetracosanoic acid, methyl ester
18.77	Squalene
18.99	Methyl 22-hydroxydocosanoate
19.21	Docosanedioic acid, dimethyl ester
19.39	Octadecane, 3-ethyl-5-(2-ethylbutyl
19.72	Hexacosanoic acid, methyl ester

Quinoa (Chenopodium quinoa) seed production under saline lands (Shortanbay site, Karakalpkstan)

What next ?:

- *Fund Rising: Seek for suitable innovative solutions and technologies* **aims to strengthen agricultural/pastures productivity in drought prone and saline environments***;*
- Evidence-based **Climate Change Adaptation strategies** for conservation and resilience of agro-ecosystems
- Hold knowledge of indigenous **Biosaline** production methods, plant species and their various uses
- *Challenges/and innovations to* and support environmental sustainability
- Rural Development (reduce poverty, *increase incomes,* ***food, nutrition and water security)*** ; New Livelihood Typologies
- **Value Chain**, environmental policy and **market relations integration**
- **Capacity Building, Knowledge Sharing and Education**

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Questions?

- THANK YOU