INTEGRATED APPROACH TO NATURE RESOURCES MANAGEMENT AND SUSTAINABLE ENVIRONMENT DEVELOPMENT IN PRIARALIE USING INNOVATIVE TECHNOLOGIES

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The social and ecological crisis in the Aral Sea zone is characterized by:

- Shrinking of the Aral Sea and large-scale desertification of a vast territory of 8 mln. ha, including the desiccated Aral Sea bed (5 mln. ha), fertile deltas of the Amu Darya and Syr Darya Rivers, the surrounding desert (Usturt), and N. Kyzylkum desert,
- Degradation and pollution of soil and groundwater, salination of soils, and decline of the crop yields in the irrigation zone,
- Disbalanced management of the transboundary water resources, diverting irrigation return water and drainage water to desert depressions,
- Degradation of pastures in Karakum, Kyzylkum deserts and Usturt plateau,

The social and ecological crisis in the Aral Sea zone is characterized by:

- Impact of residues of persistent organic pesticides (POPs) on human health, and their accumulation and migration in the environment,
- Increasing population mobility, a high rate of maternal and child mortality, rising unemployment, and worsening social conditions of the population,
- Absence of a long-range strategy of development, inadequate coordination of the officials’ activity in realization of the local and foreign projects,
- Worsening of the climatic situation, and increasing emission of harmful gases in the irrigation zone (CH_4, NO_2, N_2O, NO, CO, CO_2) and during the desertification process (CO_2) in vast areas.

1. The long-range integrated monitoring of natural resources was performed using precise equipment (AAS mass spectrometry, gas and liquid chromatography):

1.1. The dynamics of the landscapes in the dried Aral Sea bed using remote sensing during the period of 1975–2008 was deciphered by helicopters and cars, making thematical maps of vegetation, soils, subsurface waters, soil salinity, the forming sandy barkhans, wetlands, and solonchaks.

1.2. The dynamics of dust-soil aerosols transfer, deposition, and impact on natural vegetation and cultural crops was monitored for 30 years (1981–1995, 2003–2006) over a large territory (250 x 300 km2) in the southern Priaralie, using 40 sampling sites.

1.3. The methodology of ecological zoning was developed and applied in 180 regions of Uzbekistan (12 provinces of Uzbekistan and Karakalpakistan), using 20 selected indicators.

1.4. The pollutants (POPs, trace elements) were studied with respect to their migration, accumulation, and decontamination in soil, air, surface and ground waters, drainage waters, agricultural crops, drinking water, and the impact on human health.

2. The long-term measures of nature protection were tested at the pilot sites and recommended for realization in 1990–2005. They were based on new technologies including:

2.1. Mechanical and chemical fixation of the moving sands (barkhans), desalinised during 20–30 years of wind activity and precipitation, by growing seedlings of desert crops.

2.2. Creating a cascade of wetlands on the saline Aral Sea bed, with the purpose of developing productive pastures in 2–3 years (which would support round-year grazing of cattle), restoring the biodiversity of wild mammals, birds, and fish. Now 60 thousand cattle are grazing in the area of the former Sarbas and Djiltirbas bays. During humid years, natural and artificial wetlands occupy 250 thousand ha of the southern Priaralie, with a total reed biomass of 800 thousand tons.

2.3. Combined leaching and supplementary irrigation of solonchaks using saline water (2.5–6.0 g/l) for growing desert pasture crops, including the cash crop *Glycyrrhiza glabra* with a high content of glycyrrhizinic acid that is highly valued abroad.

2.4. Cultivation of perennial halophyte seedlings in the marshy solonchaks of the residual sea areas with shallow, highly saline ground waters (*Halostachys*, *Nitraria*, *Tamarix*, *Salicornia*, *Distichlis*, etc).

3. The technology of intensive aquaculture of halotolerant microalgae and the brine shrimp *Artemia* and extracting valuable salts (MgCl2, MgSO4, KCl, Na2SO4) from brine water:

3.1. The microalgae *Dunaliella* spp. may be cultivated for extracting beta-carotene, tocopherol, and other vitamins, with the resulting income of USD 1000–2000 per 1 ha.

3.2. The brine shrimp *Artemia* may be grown in the natural lakes and artificial ponds, with a monthly biomass yield of 10–20 kg/m^3.

3.3. The industrial technology of cultivating *Chlorella* algae has been developed that provides 60 tons of dry biomass per year.

3.4. The concept of aquaculture development in Uzbekistan for 2008–2016 has been worked out with the assistance of FAO. It will increase the yield of fish from 12,000 to 200,000 tons.

4. The technology of treatment of sewage, drainage, waste waters, and natural river water to remove the different kinds of pollutants (organic, biogenic, trace metals, pesticides, oil, phenol, etc.) and of reusing irrigation water:

4.1. Growing orchards and vineyards on sandy soils, using saline water (2–4 g/l) combined with biological drainage.

4.2. Growing fodder crops and fish breeding.

4.3. Providing the rural population with drinking water by using the bioengineering infiltration technology combined with local sorbent technologies.

5. The technologies of close-circle irrigation of saline soils with drainage systems, which would reuse the drainage water two or three times for growing salt tolerant crops, and then use the brine water for cultivating valuable microalgae and the brine shrimp *Artemia*, extracting various salts, or creating sun ponds to heat greenhouses (up to 90°).

6. Reclamation of saline lands, which had been excluded from irrigation, by using biological drainage, around-the-year crop rotation, mulching the soil surface with polymer film, hays, and water saving irrigation technologies (modified drip or drip-jet irrigation, reducing infiltration of water in furrow irrigation, minimal tillage, mulching after each irrigation event, etc).

7. Decontamination of POP’s residues in soil using special bacteria and fungi, growing salt tolerant desert crops for accumulation of pesticides in their biomass, cultivation of poplar species, using crops with a low rate of pesticide accumulation. The treatment of population affected by pesticide residues by manufacturing local hemo- and endosorbents, strengthening the immune system by vitamins accumulated in the microalgae, etc.

8. Optimization of the use of water, salt, and energy resources in the Amu Darya, Syr Darya, and Seraphshan rivers, using the proposed mathematical models developed jointly with the experts from the University of Texas. Implementation of the water saving irrigation and drainage technologies in the basin, artificial groundwater recharge for using them during dry months, accumulation of freshwater to be reused for irrigation.