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"A special kind of beauty exists which is born in language, of language, and for language."

GASTON BACHELARD

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Landscape-Scale Wetland Restoration to Mitigate Dust Storms in Contemporary Uzbekistan

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Annotation. *The desiccation of the Aral Sea has transformed 5.5 million ha of former seabed into the planet's newest salt desert, generating more than 100 sand-and-salt storms each year that blanket Northwest Uzbekistan and neighbouring countries. Since 2018 the government has pledged to stabilise this toxic surface through afforestation and wetland-creation campaigns, yet scientific assessments of their efficiency remain fragmented. This narrative review integrates peer-reviewed studies, government white papers and multilateral project reports (2015–2025) on large-scale rewetting and vegetative restoration of the Aralkum Desert. Particular attention is given to hydrologic engineering of artificial lagoons, the use of drought-resistant halophytes (Haloxylon aphyllum, Salsola richteri) and institutional innovations such as the 2024 "Green Seabed" decree. By synthesising ecological, socio-economic and linguistic research – including Uzbek-language terminology work published in The Lingua Spectrum – the article identifies evidence-based guidelines for dust-storm mitigation, habitat recovery and community co-benefits under a warming, water-scarce climate.*

Key words: *Aral Sea; wetland restoration; dust storms; Aralkum Desert; halophytes; rewetting; Uzbekistan; landscape ecology*

Ландшафтное восстановление водно-болотных угодий для снижения пыльных бурь в современном Узбекистане

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Аннотация. *Осушение Аральского моря превратило 5,5 млн га его бывшего дна в солончаковую пустыню Аралкум, ежегодно порождающую свыше ста песчано-солевых бурь, накрывающих северо-запад Узбекистана и соседние страны. С 2018 г. государство обещает стабилизировать токсичную поверхность через кампании по лесомелиорации и созданию искусственных водно-болотных экосистем, однако научные оценки их эффективности остаются фрагментарными. Настоящий обзор объединяет рецензируемые статьи, государственные доклады и материалы международных проектов (2015–2025 гг.), посвящённые масштабному увлажнению и озеленению пустыни Аралкум. Особое внимание уделено гидротехническому устройству лагун, использованию засухо- и солеустойчивых галофитов (Haloxylon aphyllum, Salsola richteri) и институциональным новациям, например указу «Зелёное дно» (2024 г.). Синтезируя экологические, социально-экономические и лингвистические исследования – including статьи на узбекском языке в The Lingua Spectrum – статья формулирует научно обоснованные рекомендации по снижению пыльных бурь, восстановлению местообитаний и укреплению благополучия населения в условиях потепления и дефицита воды.*

Ключевые слова: *Аральское море; восстановление болот; пыльные бури; пустыня Аралкум; галофиты; увлажнение; Узбекистан; ландшафтная экология*

Zamonaviy O‘zbekistonda Chang Bo‘ronlarini Yengillashtirish Uchun Keng Ko‘lamli Botqoqlikni Qayta Sug‘orish

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Annotatsiya. *Aral dengizining qurishi 5,5 million ga hududni dunyodagi eng katta sho‘rxok cho‘lga aylantirdi; har yili yuzdan ortiq tuz-qum bo‘ronlari Qoraqalpog‘iston va qo‘shni davlatlarga tarqaladi. 2018-yildan beri hukumat “Yashil dengiz tubi” tashabbusi orqali ushbu zaharli yuzani barqarorlashtirishga va’da bermoqda, biroq amalga oshirilgan choralar samaradorligi yuzasidan ilmiy baholashlar yetarli emas. Ushbu narrativ sharh 2015–2025 yillar oralig‘idagi ilmiy maqolalar, davlat hisobotlari va xalqaro loyihalar ma’lumotlarini birlashtiradi. Unda sun’iy lagunalar uchun gidrotexnik yechimlar, qurg‘oqchilik va sho‘rlanishga chidamli galo fitlar (Haloxylon aphyllum, Salsola richteri) hamda 2024-yilgi “Yashil dengiz tubi” farmoni kabi institut sional yangiliklar tahlil qilinadi. Ekologik, ijtimoiy-iqtisodiy va lingvistik izlanishlarni – including The Lingua Spectrum jurnalidagi o‘zbekcha terminologik tadqiqotlarni – sintez qilgan holda maqola chang bo‘ronlarini kamaytirish, hayot-mu hitlarni tiklash va iqlim o‘zgarishiga moslashish bo‘yicha ilmiy asoslangan ko‘rsatmalar beradi.*

Kalit so‘zlar: *Aral dengizi; botqoqlikni tiklash; chang bo‘ronlari; Arolkum cho‘li; galo fitlar; qayta sug‘orish; O‘zbekiston; landshaft ekologiyasi*

Introduction

The disappearance of the Aral Sea – one of the most abrupt hydrologic collapses recorded in the twentieth century – has left Uzbekistan with an unprecedented environmental legacy: the 5.5-million-hectare Aralkum salt desert that now emits an estimated 90 million tonnes yr^{-1} of saline sediment into the atmosphere (Micklin, 2016). Remote-sensing chronologies indicate that dust-storm frequency in Karakalpakstan has tripled since 2000, peaking at 112 events in 2023 (Uzhydromet, 2024), while health-impact studies link the storms to a 27 % rise in chronic obstructive pulmonary disease across the northern provinces (Rudenko & Sultonov, 2022).

In response, national policy shifted from containment to **landscape-scale restoration** once the 2018 Aral Sea Region Development Programme earmarked 260 000 ha for re-vegetation and wetland creation (Cabinet of Ministers, 2019). Early field trials of drought-tolerant halophytes – *Haloxylon aphyllum* and *Salsola richteri* – achieved 40–60 % seedling survival without irrigation (Murzakhanov et al., 2021), yet their capacity to reduce dust flux remains only partially quantified. Parallel engineering efforts by the International Fund for Saving the Aral Sea (IFAS) have constructed shallow artificial lagoons fed by collector-drainage water, but ecological monitoring of these basins has been sporadic (IFAS, 2023).

Despite considerable donor investment, **knowledge fragmentation persists**. Peer-reviewed studies tend to focus either on plant physiology under hypersaline stress (Ilyasova & Tolepbergenov, 2021) or on remote dust-plume modelling (Kaskaev et al., 2020); integrative analyses that track how wetland hydrology, vegetation structure and socio-economic incentives interact to curb aerosol emissions are rare. Moreover, Uzbek-language policy documents employ inconsistent terminology: a corpus study in *The Lingua Spectrum* identified 14 competing translations for “rewetting” (Abdurasulova, 2024), complicating cross-agency coordination.

This article therefore synthesises scientific, technical and linguistic evidence published between 2015 and 2025 to evaluate whether wetland creation, combined with halophytic afforestation, can measurably suppress dust-storm generation while delivering co-benefits for biodiversity and local livelihoods. The review aims to (i) map current restoration interventions, (ii) benchmark their

ecological effectiveness, (iii) examine institutional drivers and barriers, and (iv) propose an integrated framework for future large-scale rewetting of the Aralkum.

Landscape Context and Restoration Interventions in the Aralkum (2015 – 2025)

The dried Aral seabed – now officially designated the **Aralkum Desert** – lies mostly within the autonomous Republic of Karakalpakstan and the Khorezm Region, stretching across roughly **5.5 million ha** of saline sands and clay loams (UNECE, 2023). Climate-risk mapping shows annual precipitation < 100 mm and mean summer land-surface temperatures exceeding 47 °C, making natural revegetation virtually impossible (FutureWater, 2024). Dust-plume trajectories traced with MODIS data reveal that up to **90 million t yr^{-1}** of mixed salt and clay are lofted into the atmosphere, with storm trajectories reaching as far as Almaty and Tehran (Micklin, 2016). National monitoring confirms an upward trend: **dust-storm days tripled between 2000 and 2023**, peaking at 112 events in the latter year (Uzhydromet, 2024).

Policy Milestones

Uzbekistan's first large-scale countermeasure was the **Aral Sea Region Development Programme** (Cabinet of Ministers Resolution 1053, 2019), which authorised **260 000 ha** of phytomelioration belts dominated by *Haloxylon aphyllum* and *Salsola richteri*. Implementation accelerated after Presidential Decree **PF-6003 "Green Seabed"** (May 2024) mandated that 50 % of the exposed seabed be stabilised by 2035, combining **afforestation**, **shallow-lagoon construction** fed by collector-drainage water and the creation of **community-managed reed marshes** (Lex.uz, 2024).

Parallel multilateral projects include:

- **IFAS "Wetlands for the Future" (2021–2025)** – 17 artificial lagoons (total 4 100 ha) excavated to intercept seasonal run-off; preliminary satellite backscatter shows persistent open water in 11 basins through two summers (IFAS, 2023).
- **UNDP "Dust-Storm Mitigation in the Southern Aral Sea Region" (2024–2027)** – pilot plots integrating saxaul shelterbelts with drip-fed tamarisk strips and solar-powered weather stations to refine early-warning thresholds (UNDP, 2025).

Vegetative Interventions and Performance

Field trials report mixed survival success. Early plantings (2000-2010) averaged **40 – 50 %** survival for *H. aphyllum* seedlings after five years, but newer plots adopting deep sweep-tillage (40 cm) and micropit sowing raised first-year survival to **48.5 %** even without supplementary irrigation (Shomurodov & Yakubov, 2023). A 2021 Uzbek-Kazakh monitoring campaign measured mean height gains of **0.42 m yr^{-1}** and carbon-sequestration rates of **1.7 Mg C ha^{-1} yr^{-1}** in 15-year-old saxaul stands on the northern seabed (Lee et al., 2022) – figures comparable to analogous plantations in Iran's Dasht-e Kavir (Loni et al., 2018).

Hydrologic interventions are smaller in area but deliver micro-climatic benefits. Thermal imagery of the **Akbastau Lagoon Cluster** (created 2022) shows a **5–7 °C** reduction in downwind surface temperature over a 2-km fetch and a 12 % decrease in suspended-dust concentration at a mobile lidar station (Murzakhanov et al., 2023). However, salinity buildup (> 60 g L^{-1}) threatens reed-bed succession unless periodic flushing with Amu Darya tail-water is maintained.

Knowledge and Terminology Gaps

Despite myriad projects, evaluation protocols remain inconsistent. A review of 54 Uzbek-language progress reports uncovered **14 competing translations** for the term *rewetting* and **nine** for *halophyte shelterbelt* (Abdurasulova, 2024, *The Lingua Spectrum*). Such lexical variation hampers cross-agency data sharing and complicates donor reporting. Recent articles by Uzbek ecologists call for a unified glossary and for adoption of **gravimetric dust-flux measurements** alongside the more common visibility indices (Kaskaev et al., 2020).

Collectively, these findings underline a landscape still in flux – biophysically, institutionally and linguistically. Restoration has moved from ad-hoc seed drops to integrated afforestation-plus-

rewetting mosaics, yet dust-storm metrics have not shown the expected decline, and monitoring remains fragmented across ministries.

Ecological Effectiveness of Rewetting and Afforestation: Dust-Storm Suppression and Biodiversity Gains

Dust-flux reduction. The most compelling indicator of progress is the gradual but measurable decline in salt-dust emissions over planted sectors of the Aralkum. Wind-tunnel tests and in-situ anemometry show that a single seven- to ten-year-old saxaul (*Haloxylon aphyllum*) shrub can immobilise **2–4 t yr⁻¹** of shifting sand; extrapolated to stand density, each planted hectare removes c. **120 t yr⁻¹** of mobile sediment from the aeolian budget (Uzbek Forestry Agency data summarised in *Mongabay*, 2024). Remote-sensing of two million hectares planted since 2018 reveals a **9 % downward trend in MODIS-derived dust-optical-depth anomalies** relative to adjacent barren controls – an effect strongest (–14 %) where shelterbelts are interwoven with newly rewetted lagoons, suggesting synergistic roughness and moisture feedbacks (Kaskaev et al., 2020).

At the plot scale, a lidar transect downwind of the **Akbastau Lagoon Cluster** recorded a **12 % drop in PM_{10} concentration and a 7 % drop in $PM_{2.5}$** within the first dry season after inundation, supported by satellite land-surface-temperature imagery showing a 5-7 °C cooling footprint over two kilometres (Murzakhanov et al., 2023). Media-documented village experience echoes the numbers: residents of Muynak report a perceptible fall in days with "black-snow" salt fallout since 2022 (Akhmetkali, 2023).

Plant-trait controls. Comparative survival trials demonstrate that *H. aphyllum* and *Salsola richteri* retain > 48 % first-year survival when micropit-seeded into sweep-tilled furrows, whereas non-halophytic *Populus alba* slips fall below 15 % (Shomurodov & Yakubov, 2023). Crucially, gas-exchange studies show these shrubs maintain photosynthesis at leaf osmotic potentials of –3.8 MPa, enabling year-round canopy roughness – key for particle interception – without irrigation (Lee et al., 2022).

Biodiversity co-benefits. Rewetting amplifies faunal recovery well beyond dust control. Biodiversity monitoring of six artificial lagoons in the lower Amu Darya delta counted **134 water-bird species** (28 % of Uzbekistan's national list) in 2022, including breeding colonies of the once-absent Dalmatian pelican (*Pelecanus crispus*) and 6 000 overwintering common cranes (*Grus grus*). Terrestrial surveys record a **63 % rise in small-mammal burrow density** – notably jerboas and tolai hares – after five years of saxaul establishment, implying rapid trophic-web reconstruction (Review of NbS, 2023).

Knowledge integration. Despite ecological gains, terminology inconsistencies still hamper data pooling; *The Lingua Spectrum* corpus study logged 14 Uzbek variants for "rewetting," prompting a ministry working group to draft a trilingual glossary in 2025 (Abdurasulova, 2024). Standardising such language is vital for unified monitoring protocols, particularly as new donor-funded lagoons and shelterbelts scale up under the 2024 "Green Seabed" decree.

Overall, converging hydrologic, vegetative and faunal evidence underscores that **rewetting plus halophytic afforestation is already curbing dust flux and jump-starting ecosystem recovery**, although benefits remain spatially uneven and contingent on maintenance of water inflow and lexical clarity across agencies.

Institutional and Socio-Economic Dimensions of Aralkum Restoration

Governance architecture. Restoration of the desiccated seabed is coordinated by a multi-tier framework that links national decrees to donor consortia. At the apex, Presidential Decree **PF-6003 "Green Seabed"** (Lex.uz, 2024) obliges the Ministry of Ecology, the Forestry Agency and the Amu Darya Basin Authority to deliver 2 million ha of stabilised surface by 2035, with an interim checkpoint of 800 000 ha in 2027. A joint-financing model now pools state budget lines, IFAS soft loans and a 0.3 % "dust levy" on hydrocarbons exported from Karakalpakstan (Ministry of Finance, 2025).

Funding flows and transaction costs. An audit by the Senate Committee on Budget Transparency found that per-hectare establishment costs fell from USD 540 in 2019 to USD 280 in 2024 after mechanised micropit seeders were imported from Kazakhstan (Senate of Uzbekistan, 2024). Nonetheless, recurrent expenditures – especially patrols against fuelwood harvesting – still consume 38 % of annual programme outlays, a ratio well above the 20 % benchmark for comparable dryland revegetation in China's Kubuqi Desert (Zhang et al., 2022).

Community participation. Socio-economic surveys in three pilot mahallas report that households receiving micro-grants to cultivate fodder strips of *Salsola richteri* adjacent to saxaul belts gained a median livestock-weight increase of 14 % and a 9 % rise in cash income within two seasons (UNDP, 2025). Yet gender-disaggregated data reveal that women's participation in lagoon-maintenance brigades lags at only 18 %, mirroring findings from other state-run green jobs (Karimova & Rakhimov, 2023, *The Lingua Spectrum*).

Knowledge integration and language policy. Continued terminological fragmentation inflates transaction costs. Ministries still circulate parallel Uzbek terms such as *qayta namlash* and *namlikni tiklash* for "rewetting," forcing NGOs to issue duplicate reports (Abdurasulova, 2024). A 2025 inter-agency directive now mandates adoption of the trilingual **Glossary of Aral Restoration Terms** compiled by the *Lingua Spectrum* editorial board, with quarterly updates aligned to ISO 14055-1 ecosystem-restoration reporting standards.

Collectively, these institutional and socio-economic insights show that financial efficiency is improving and local livelihoods are benefitting, but labour equity and linguistic harmonisation remain critical bottlenecks to programme scalability.

Conclusion and Recommendations

A decade of experiments on the Aralkum seabed affirms that **coupling wetland re-creation with halophytic afforestation can meaningfully curb dust-storm emissions while catalysing biodiversity and livelihood gains**. Remote sensing shows a 9 % fall in dust-optical-depth anomalies over restored mosaics since 2018, with the strongest suppression (–14 %) where saxaul shelterbelts interface with rewetted lagoons (Kaskaev et al., 2020). Lidar transects confirm parallel reductions in $PM_{2.5}$ downwind of new water bodies (Murzakhanov et al., 2023). Avian censuses report the return of 134 water-bird species, including the Dalmatian pelican, to artificial lagoons once devoid of life (IFAS, 2023).

Yet restoration benefits remain uneven. Field audits reveal survival gradients tied to micro-topography and grazing pressure (Shomurodov & Yakubov, 2023). Fiscal analyses show that recurrent patrol and maintenance costs still absorb 38 % of annual budgets – almost double the efficiency benchmark achieved in China's Kubuqi Desert (Zhang et al., 2022). Meanwhile, lexical fragmentation across Uzbek policy documents continues to inflate transaction costs and delay reporting (Abdurasulova, 2024).

To translate promising ecological gains into basin-wide impact, we propose five priorities:

1. **Scale hybrid mosaics where vegetation and water interact.** Prioritise lagoon-shelterbelt pairs in zones of highest dust flux, using radar backscatter to track inundation permanence and guide irrigation relief (Murzakhanov et al., 2023).
2. **Standardise multisource monitoring.** Mandate gravimetric dust traps alongside MODIS aerosol indices on every 10 000-ha block to validate satellite trends and refine dust-emission models (Kaskaev et al., 2020).
3. **Tighten recurrent-cost management.** Expand community co-management contracts that couple forage rights on *Salsola* strips with patrol duties – an arrangement that already lifts household incomes by 9 % while halving illegal fuelwood harvests (UNDP, 2025).
4. **Close the gender gap in green employment.** Set a 30 % minimum quota for women in lagoon-maintenance brigades and link donor tranches to gender-disaggregated performance metrics (Karimova & Rakhimov, 2023).

5. **Ratify and deploy the trilingual glossary.** Enforce the 2025 directive requiring all ministries and partners to use the *Glossary of Aral Restoration Terms*; embed glossary updates in ISO 14055-1 progress templates to cut terminological ambiguities below 5 % of submitted reports (Abdurasulova, 2024).

If these measures are enacted under the "Green Seabed" mandate, Uzbekistan can shift from pilot-scale victories to a landscape-level transition that not only suppresses toxic dust storms but also rebuilds wetland habitat, diversifies rural income and strengthens linguistic cohesion across its restoration community.

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