NATIONAL ACTION PLAN

FOR MITIGATION OF SAND AND DUST STORMS' EFFECTS IN THE REPUBLIC OF UZBEKISTAN

FOR

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Disclaimer:

Developed by: **Green World Future**

- **Alijon S. Ravshanov** – National Coordinator for the Project
- **Khojimurat M. Talipov** – Deputy Head of the Department to Combat Desertification and Drought, State Committee for Forestry, PhD in Biology
- **Sobirjon M. Umarov** – Head of the Department to Combat Desertification and Drought, State Committee for Forestry
- **Sanjarbek M. Muratov** – Geodetic Engineer, Cadastre Agency under the State Tax Committee
- **Abrorkhon Kh. Nozimov** – Chief Specialist, Department of the State Forestry Cadastre and Land Reclamation, State Committee for Forestry

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We also would like to thank National Working Group and staff of the State Committee on Forestry acting as the National Coordination Center of the United Nations Convention to Combat Desertification (UNCCD) for their coordinating support in obtaining necessary data and materials from the relevant ministries and entities and developing this National Plan.

We express our special gratitude to all the experts of the UNCCD Secretariat and the Regional Environmental Center for Central Asia (CAREC) for the valuable comments as well as for coordination and support while developing this National Plan.

National Action Plan for Mitigation of Sand and Dust Storms' Effects in the Republic of Uzbekistan shall pass procedure of approval by the Government of the Republic of Uzbekistan as established by law, and, hopefully, National Working Group shall complete this process soon.

Once again, we would like to express our sincere gratitude to the UNCCD Secretariat. Development of this National Action Plan for Mitigation of Sand and Dust Storms' Effects became possible thanks to financial support kindly rendered by this organization.

Best regards,

N.J.Bakirov
Chairman, State Committee on Forestry of the Republic of Uzbekistan

Contents

ABBREVIATIONS

AS	Academy of Sciences
GIS	Geographic information systems
SCSC	State Committee of the Republic of Uzbekistan For Sciences and Technology
RSChS	State System of Prevention and Response to Emergency Situations
GEF	Global Environmental Facility
ICARDA	International Center for Agricultural Research in The Dry Areas
CACILM	Central Asian Countries Initiative for Land Management
UNCCD	UN Convention to Combat Desertification and Droughts
UNCBD	UN Convention on Biological Diversity
CM	Cabinet of Ministers
ME	Ministry of Emergency Situations of the Republic of Uzbekistan
NGO	Non-governmental non-profit organizations
NAP	National Action Plan
NAPEP	National Action Plan on Environment Protection
DDD	Desertification, land degradation and drought
PA	Protected Area
DS	Dust storm
MAC	Maximum Admissible Concentrations
RCM	Resolution of the Cabinet of Ministers
DD	Drifting dust
SDS	Sand and dust storms
UNDP	UN Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
DAP	Dry atmospheric precipitations
SP	Solid Particles
FAO	Food and Agriculture Organization of the United Nations
CA	Central Asia
SDG	Sustainable Development Goals
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
MODIS	Moderate Resolution Imaging Spectroradiometer
TSAVI	Transformed Soil Adjusted Vegetation Index

PROJECT DETAILS

“Regional approaches towards combating sand and dust storms and drought in Central Asia” project is funded by the UNCCD Secretariat and performed by CAREC.

The Central Asian countries (CA) are significantly impacted by droughts, sand and dust storms (SDS), especially areas outside highlands where semi-dry and dry climate prevails. Recognizing increasing droughts and SDS risk, UNCCD Parties resolved on combating negative impact of droughts and SDS.

To support member countries in boosting their preparation and resilience towards droughts and SDS and enabling environments for taking coordinated actions and exchange in data at national and regional level, the Secretariat of UNCCD developed mechanisms to promote policies to combat droughts and SDS, reinforce countries in developing national plans, methodologies and tools to combat droughts, including complex measures to combat droughts as well as complete list and global surveillance map of SDS sources.

Initiative by the Secretariat of the UNCCD for the Central Asia is aimed to support countries of the region in developing and introducing strategies to mitigate SDS and droughts risks on national and regional levels, and promotes coordinated actions between government entities working in climate and environment related area, academic community, practitioners and local communities.

With comprehensive strategy on droughts and SDS risks mitigation, including monitoring and early warning system, the countries of the Central Asia shall be able to strengthen regional integration and potential to boosting the preparedness and resilience towards corresponding environmental and natural disasters efficiently, focusing on preventive management as per the national plans for reduction of disasters risks and adverse impacts mitigation as well as according to the national plan for land, water and other natural resources management.

Noteworthy, the UNCCD Secretariat and CAREC recognize the role of women in implementation of the Convention and other environmental initiatives and, thus, defined following areas critical for engaging women, namely: (i) raising women's awareness and participation in developing and introducing the programmes; (ii) processes of making decisions which men and women introduce at local level while managing, developing, introducing and assessing regional and national action plans (RAPs and NAPs); and (iii) enhancing potential, training and raising public awareness, particularly at the local level while supporting local organizations.

INTRODUCTION

At first glance territory of Uzbekistan can be divided into mountainous and plain terrains. Mountainous terrains are the areas of ancient and contemporary tectonics, contortions, intensive erosion, and of accumulation, to a certain extent. Typical mountain relief with abrupt elevation changes, steep cleves, deep hollows and shart chines prevail in these areas. Plain terrains areas are flat surfaces of dried-up sea sediments or ancient fluviatile or lacustrine inundation which took place well after intensive folding or other movements of the Earth's crust. The predominant part of plain terrains area was formed due to erosion and accumulation processes. Notwithstanding small absolute elevations typical forms of mountainous relief can be observed in these areas. Such regions are called desert low hill terrains.

Sand ripples were the primary form of eolian relief on bare sand surface. The next one was sand waves and barchan chains which definitely have to be distinguished from barkhan sands by their origin and genesis. Barkhan sands are often encountered at delta dense clay areas near oasises as well as on the edge of major salt marshes and takyrs. Barchan chains are their large forms representing mature stages of aeolic relief development.

Technogeneous relief-forming processes are linked with the direct anthropogenic influence produced on relief and are mainly presented with such forms of relief as water supply and irrigation channels, earthfills alongside channels and roads, major borrow pits, water reservoirs' dams and etc. Due to these processes taking place, particularly, in irrigated agriculture landscapes, irrigation-specific relief is formed, deltaic relief is levelled and flattened, irrigation channels rampart mesoforms, pit-like irrigation depressions develop.

Being originated naturally by the essence, technogeneously induced processes are directly linked to desertification processes and emergence of soil deflation centers, though they are anthropogenically-induced. Alongside with construction of roads, drilling wells and etc., such anthropogenic impacts as cattle grazing and tree and shrub vegetation cut for fueling purposes are playing key part in sand flats relief formation in the deserts of Uzbekistan as well as in aeolian processes development.

Denudation processes and barkhan forms emergence as an outcome of overgrazing and shrubs cut takes place in several stages. At initial stages the major sand binding plants (Carex lasiocarpa, Carex physodes) layer continuum is disturbed and barren sands spots emerge. At the second stage Carex physodes disappear completely with sand occasionally forming barkhans. At the third stage bare barkhan sands almost completely left without vegetation emerge. Nowadays this can be observed around wells and residential settlements in desert and semidesertic regions of Uzbekistan.

Desertification, soil degradation and barren barkhan sands are the driving engines for SDS. Unstable land and water use, extreme wind phenomenons and severe drought are the major factors worsening SDS. The main reason for SDS is wind structure-determined turbulence facilitating dust and sand particles being easily lifted from the land surface. Here a degree of vertical instability of air is important, since dust and sand storm is developing within. Severe daytime heating of lower layers of air in summer leads to significant increase in temperature gradients up to 1—1,5 km altitude above steppes and 2—2,5 km altitude above deserts. Convective mixing extending up to these altitudes strives to distribute sand and dust particles lifted up from the land surface across all the layer it covers. Minor particles creating mist can rise very high, while the heavier ones have smaller elevation altitude and quickly fall back to a land surface.

SDS causes animals death and damages plants, destroying topsoils and reducing its agricultural productivity. In some cases after this phenomena area relief may change. Amount of sunlight reaching Earth's surface is decreasing, atmosphere is polluted. Dust storm also affects human

health: we can breathe in tiny particles of this dust, and, depending on their composition, have our lungs damaged to a certain extent.

Nowadays, UN World Meteorological Organization (WMO) can warn on storms approaching three days before. However, the countries still need to handle vulnerable population groups warning by themselves in order to reduce mortality and damage to people's lives. WMO members are at the forefront of SDS impact evaluation and developing products enabling to elaborate guidelines to ensuring preparedness, adjustment and impact mitigation policy.

For the Republic of Uzbekistan with 70% of its territory or 31,4 mln. ha nowadays composed of arid (dry) and semi-arid areas exposed natural salinification, expansion of shifting sands, Dust storms and hot dry winds, drought and SDS combat related issues hold priority importance to ensure sustainable development of the country. Shifting sands occupy around 1,0 mln. ha, of which 200 thousands ha have recently appeared on the periphery of irrigated areas posing significant challenge of desertification processes acceleration. Land degradation occurs even on irrigated areas involved in agricultural production. Over 50% of irrigated lands are the subject of secondary salinification. Water-induced erosion is developing on the area of more than 1,0 mln. ha of croplands.

These circumstances are the reason for proactive participation of the Republic of Uzbekistan in developing and implementing of UN Convention to Combat Desertification and Drought. With the technical and methodical support from UNCCD the Government of Uzbekistan has previously undertaken several initiatives aimed at managing adverse impacts of drought and desertification; however, by now in SDS area no document have been approved to define actions to manage SDS impacts and based on this to furtherly charge corresponding missions to the relevant entities.

This National Action Plan to prevent and mitigate SDS impacts includes comprehensive analysis of the reasons of the major SDS centers emergence across the country, and defines priority actions to combat them alongside with tabling measures to mitigate social and economic impacts of SDS.

National Action Plan to prevent and mitigate impacts of SDS in Uzbekistan meets the whole range of national and sectoral strategies and programs, including Strategy on five priority directions of development of the Republic of Uzbekistan in 2017-2021, approved by the Decree of the President of the Republic of Uzbekistan No.4947 dated February 7th, 2017; Concept of Forestry System Development in the Republic of Uzbekistan by 2030; Concept of Agriculture Complex Development in Republic of Uzbekistan by 2030; State Program on Irrigation Development and Improvement Of Meliorative Conditions of Irrigated Lands in 2018-2019; Action Plan on Environment Protection in the Republic of Uzbekistan in 2013-2017; State Program on Aral Sea Region Development in 2017-2021 and etc.

1. COMPREHENSIVE ANALYSIS OF SDS IMPACT ON WELLBEING IN UZBEKISTAN

1.1. Lithologic features' impact on SDS development (mechanic and lithologic composition of soils)

Dust storm (DS) is phenomena of strong gusting whirlwinds lifting above to the air significant amount of dust, sand and other solid particles in suspension, thus, deteriorating view up to 1-2 km, and sometimes to hundreds of meters ahead. At first, limited view up to 1-2 km begins from the land surface and stands up to 1,5 – 3 km altitude from windward of the crests.

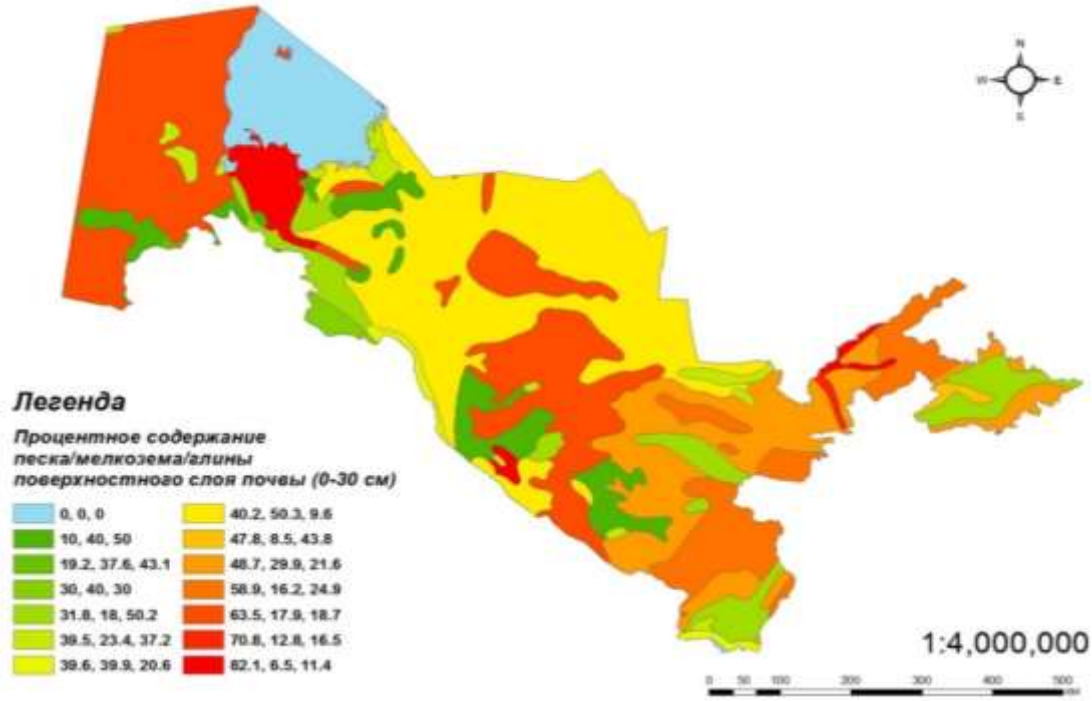
At the territory of Uzbekistan there are major natural sources of dust emissions to the atmosphere, such as poor binded sand soils and surface salt marsh layers of Karakum, Kyzylkum and Aralkum (dried-up part of Aral Sea) deserts. Aeolian sand and salts leakage from the dried up Aral Sea bed only makes up in average 40-45 mln. tones a year with major dust and sand particles leakage occurs within the 300 km of seashore. Amount of dust falling on soils in Southern Aral Sea is ten times bigger comparing to irrigated zone. Sulfates content in Aral Sea dust reaches up to 25-48%, chlorides - 18-30% and carbonates - 10-20%. [2]

For a long time soils were investigated in various aspects, namely, their geography, conditions of formation, physical and chemical properties, biological features, productive capacity, reaction to different types of fertilizers and etc. However, this wide range evidence-based data is multidimensional, compiled in various regions in different periods. Moreover, it fixes outcomes of changes took place in preceding extensive farming period. Meanwhile, processes in irrigated soils are developing at even more dynamic path. This is especially concerns intensive agricultural farming during last three or four decades resulting in drastic changes of soil-forming processes. Last comprehensive classification of soils in Uzbekistan was made in 1960s [Appendix 4].

Soils in Uzbekistan mostly vary across latitudes and altitudinal zones, which, in their turn, are depend on certain climate conditions and vegetation layer. Due to climate condition and aridity approximately 14,6 mln. ha (32% of soils of all types) are represented by soils of desert type (grey-brown desert soils, sandy and takyr soils and their subtypes).

Salinified soils (salt marshes and its subtypes) are wide spread in Karakalpakstan and Aral Sea region, occupying 1,3 mln. ha (3%) and prevail in local depressions located in plain terrains, lake basins and between mountains. Sands cover over 12 mln. ha (around 28% of total area) in Uzbekistan. [4]

Sierozemic belt soils (light, regular and dark ones) are distributed on 6,7 mln. ha (15%) alongside lower edge of piedmont plains with altitude range from 200 to 700-900 m above sea. Soils of these types have high humus substance content (2-4%) and are less exposed to salinification, around 5% of lands (2,2 mln. ha) are represented with kastanozems, brown and light brown soil types in mountains where altitude ranges from 1200 to 1600 my above sea, which are exposed to erosion.



Picture 1. Mechanical composition of soils according to FAO-DSMW recalculated to sand/fine earth/clay percentage content [4]

Chart data on mechanical composition of soils, according to UN FAO, shows that high clay and fine earth percentage content means higher potential for SDS formation [5]. Classification of soil texture types containing fine earth particles indicates on the amount sufficient for dust blowing and SDS formation, with clay and fine earth content up to 20 % and sand share up to 80 %. According to this theory, soils with relatively high clay and fine earth content are thevpotential sources of SDS formation [Picture 1].

Surfaces with prevailing sand content shall not be subject to exception, and shall be taken into account as less productive comparing to surfaces with higher content of clay and sierozem due to strong winds blowing less frequently to activate sand particles emission.

1.2. Impact of climate conditions change on SDS processes development

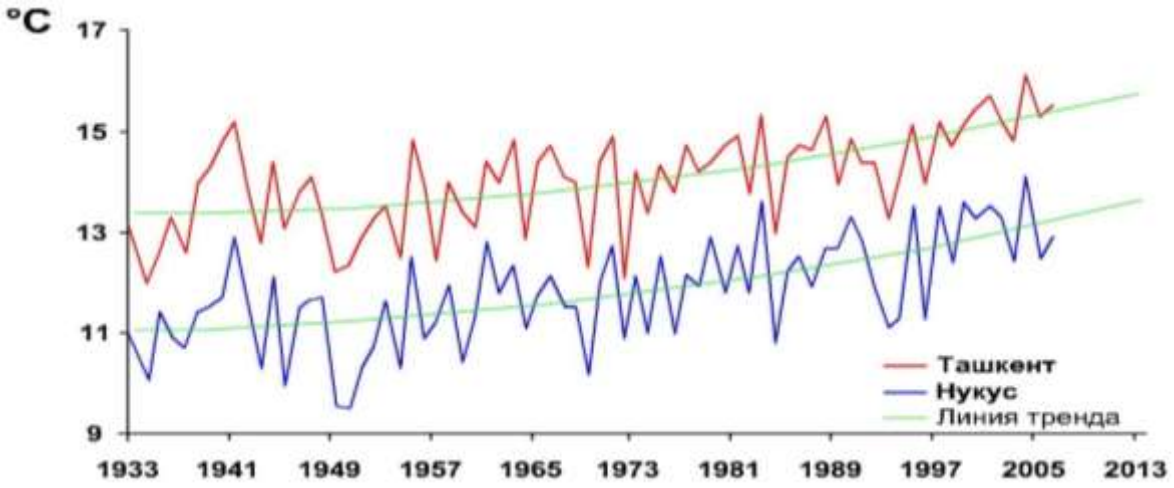
Desertification processes produce significant impact on SDS emergence. In its turn, desertification is caused by interaction of natural and anthropogenic factors. Intensity of their impact determine duration, scale and degree of desertification. In environmental and economic conditions of a certain region on of the factors can prevail. In certain conditions natural factors create preconditions for desertification processes development. Meanwhile, climate related factors dominate.

In climate regime of extremely arid areas desertification processes can accelerate even to a possibly catastrophic occasions, while severe arid and arid areas have favorable conditions for desertification. This is determined by high values of temperature and air dryness, negligible amount of atmospheric precipitations in arid regions and their unequal distribution during a year as well as exceptionally high annual and interannual variability. Specifically, sometimes precipitations fallen within one month significantly exceed those for a whole dry year.

Number of dry months a year is an important feature to assess natural hazard of desertification in arid regions. Less desertification hazard is specific to regions with up to 3 dry months, medium

one - to those with 4-7 months, strong hazard - to those with 8-9 months and extremely strong - to those with more than 9 dry months.

In Central Asia's natural conditions accumulation of grazing vegetation mass depends on warmth and water availability of the areas. Major factor determining vegetation growth degree is the amount of precipitations. Due to extreme aridity ephemeral plant do not grow at all, monocyclic salsola sprouts perish before rooting properly, shrub plant is depressed. Thus, even in natural conditions favorable environment for desertification emerges.



Picture 2. Average annual air temperature change in Uzbekistan [7]

Drought of various severity annually occur across plain terrains in Central Asia. In most cases hot dry wind induced dry air peak in July. Based on this fact conclusions can be drawn on hot dry wind occurrence frequency during several years period. Phenomena of intensive hot dry wind called Garmsil (harmsel) often occur in the region producing oppressing impact on vegetation. Garmsil is very strong fohn. In the regions where garmsil is accompanied with increase of wind, in dry summer season Dust storm emerge looking like as if they were creeping on the ground.

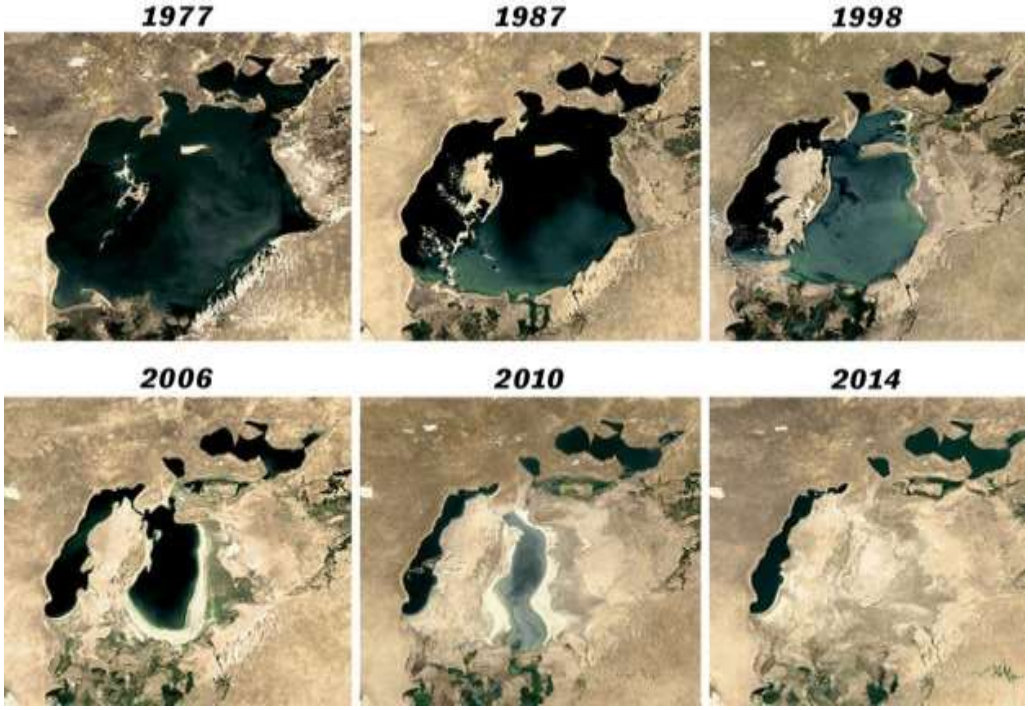
The major or one of key mechanisms intensifying desertification processes while hot dry winds is the impact of you wind (dry wind flow) itself carrying salts, dust and sand in suspension and by rolling particles on the land surface. In such transporting activity three phases can be distinguished: breaking down or deflation, repurification or transflation and drifting or simflation, i.e. aeolic accumulation.

Due to major water withdrawal for irrigation reverse effect, i.e. desertification effect occurs in Aral Sea region, where significant reduction of water inflow resulted in dramatic drop of sea level and shrinking of its area. Anthropogenic local climate changes, which took place during sea degradation period, are as follows.

Regarding atmospheric precipitations sea withdrawal impact reflected in changed ratio of warm and cold period precipitations. Previously summer precipitations dominated above the sea, nowadays wintertime precipitations are formed more often. Since spring and autumn time anthropogenic temperature changes have different intensity (and positive or negative range) heat resources for all the vegetation period in seashore area remained stable for a long time. In 1981-1990s, when sea withdrew from the shore for 25-26 km (Muynak and Uyaly respectively) and impact of summertime anthropogenic warming increased, efficient temperatures summ here rose by 30-50°C comparing to «non-disturbed» period.

Relative humidity changes were the most obvious ones in Aral Sea region,especially in south and east coast, where relative humidity difference as compared to the desert in «non-disturbed» mode

totaled 35-40%, and 20-28% after 1990. Anthropogenic contribution is comparable to the natural one, exceeding it in some settlements (Uyaly).



Picture 3. Aral Sea drying-up trend

All the listed manifestations of anthropogenic climate change are observed in the zone surrounding Aral Sea on up to 100 km distance away from the initial (before 1960) coastline. Still, no evidence was identified hinting on contribution of sea degradation on number of clear days fluctuations, radiation parameters and atmospheric precipitations in Aral Sea region. This processes in Aral Sea region commenced in 1960, i.e. in the same period with the general atmospheric circulation phases change. Therefore, in areas with intensive irrigation «oasis impact» was oppressed, while in Aral Sea region desertification effect was worsened with natural climatic trends.

As an outcome of Aral Sea dry-up annual dust emissions to the atmosphere increase. While strong Dust storms dust emissions level total 1,5-6,5 t/ha depending on the distance with toxic salts content ranging from 260 to 1000 kg/ha[1].

Desertification expansion also increase amount of open textured sand and dust which can be taken by the wind resulting in SDS. Dust storms in Central Asian countries are happening more often, becoming more intensive recently as precipitations amount reduction in long term causes decreasing soil humidity and vegetation layer. SDS may produce adverse impact on climate, accelerating desertification. Dust particles in the air disseminate radiation emitted by the Sun. Dust can temporarily absorb ground temperature, but air temperature will increase. This can distort and decrease clouds lifetime, reducing amount of precipitation. For around 40% of tropospheric (the lowest layer of the Earth' atmosphere) aerosols and gases are made of wind erosion-induced dust particles. Aerosol, particularly mineral dust affects weather as well as global and regional climate. Dust particles, particularly polluted ones, act as condensation nuclei to produce warm clouds and as efficient agents of ice nuclei to for cold clouds.

[1] National Action Plan to Combat Desertification in the Republic of Uzbekistan. UNEP/Uzhydromet. 1999. (in Russian).

1.3. SDS processes impact on social and economic development of the country

Under SDS air-borne dust poses a significant threat to people's health. Dust storms can favour certain respiratory diseases, such as pneumonia, dermal irritation, asthma and many others. According to the assessment in the framework of global model, in 2014 impact produced by dust particles caused 400 000 early deaths of cardiovascular origin among population above 30. Some infectious diseases can also be transferred by dust. Researchers believe that by breathing in dust particles while hot dry weather can damage nasal and throat mucosa, creating favorable conditions for bacterial infection. Moreover, ferrous oxides in dust particles can increase risk of contamination.

Khorezm province and the Republic of Karakalpakstan are the regions with the highest extent of exposure to SDS impact in Aral Sea region. Disease incidence totals 72,3 % of population in Khorezm province and 70% in the Republic of Karakalpakstan. In Khorezm province over 370,000 people (37% of medically observed population) were included in potentially vulnerable to diseases risk group, in the Republic of Karakalpakstan this number exceeded 550,000 (45% of medically observed population).

In Aral Sea region tuberculosis, esophageal cancer, blood and hematopoietic system, digestive system diseases incidence exceeds country average several times. Oncologic diseases incidence drastically increased in the Republic of Karakalpakstan, substantially affecting economy and working age groups of population. Within the last couple of years, in the Republic of Karakalpakstan 15-16 thousands of people face malignancies of different locations and 10-11 thousands of them die from cancer annually. Worrying trend towards increasing rate of lungs, breast, skin, lymphatic and hematopoietic bodies, colon cancer occurence is observed. Unfavorable ecological and hygienic conditions in several cities and administrative districts is determined by large scale adverse effects of natural and anthropogenic factors, including SDS.

Ecological problems of Aral Sea region cause social vulnerability of the region's population. This situation is worsened by SDS impact due to unstable living conditions and limited access to resources and opportunities, as an outcome reducing productivity in the main domains of people's economic activity, namely agriculture, cattle-farming, fishing and etc. SDS pollute open water sources, decreasing efficiency of efforts to use clean energy and burdening movement of the most of transportation means.

According to the research conducted by the Institute of Social Research under the Cabinet of Ministers of the Republic of Uzbekistan, employment is the major problem for Aral Sea region. Vulnerability rate here totals 32,5v%. Other key problems include pollution of potable water, soils and air. Ensuring population's access to good-quality potable water is crucial. Research showed that over 30 % of people rate water quality as unsatisfactory. Main reasons for this are unstable water supply (26,9 %), poor quality of water (37,8 %), remoteness of water sources (19,0 %). 60 % of respondents pointed out lack of water conduits in the areas covered by research. Mentioned reasons serve as the main directions for managerial decision-making and satisfying need in the most required and socially important resource for population, i.e. potable water. Moreover, underdeveloped transportation infrastructure, healthcare and education, particularly, expensive medicines and lack of qualified specialists were also included in the list of crucial problems.

Population discontent with the access to gas and fuel supply is caused by unstable gas supply and irregular delivery of liquified gas tanks. Population mostly prefers to use liquified gas delivered in tanks due to its environment friendliness and easy delivery. According to poll, 79,1% of households have no special bathroom for taking shower and washing in it since it requires engineering solutions under reconstruction and construction of houses. Residential construction in rural areas has its own features related to climate and ecology, which require development of a new construction norms and rules and design system taking into account local conditions.

Agriculture remains the major source of income for the most of desert communities. Desertification growth and frequently occurring SDS in Aral Sea region caused land degradation to an extent that people can not work in agriculture and gain profit. This has affected economy and raised poverty level. As an outcome, agricultural land in the region became incapable to sustain the same number of population as it did early. A lot of residents of these regions move to urban areas or to Russia or Kazakhstan. According to the research, in average 19,8 % of households have one of their members staying abroad. Notwithstanding the decreasing trend of population shifting (from 23 thousands of people in 2012 to 14,4 thousands in 2016) abroad, this indicator here has the highest value comparing to others regions.

Nowadays 50 % of irrigated lands across the country are exposed to certain degree of salinification, while 19 % of lands are under the threat of soil erosion. Salinification reduces cotton harvest for 20-30% on slighty saline, for 40-60 % on moderately saline and for over 80 % on severely salinified lands. High ground water level, incorrect irrigation and negligible funding of drainage system maintenance increase salinification degree, producing adverse impact on agricultural crops production. Such shrinkage if resource base is estimated to reach 1 bln USD annually as a profit lost due to land degradation. [22] These losses often are related to lack of necessary information in required timeframe in a form suitable for rights and timely decision making by government authorities.

Objective region-specific factors hindering sustainable development of entrepreneurship are remoteness of residential settlements and low population density, weak minerals and raw materials base in rural areas, poor quality of water and land resources and bleak entrepreneurship activity of population. According to the results of the research, only 25,9 % of respondents prefer to do business (country average - 49,5%).

Uzbekistan implements measures aimed to enhance women's social activity, boosting women's employment, strengthening family relationships, maternity and childhood protection. According to the poll, share of economically active women totaled 48,1 %. Women are mostly employed as teachers, doctors, preschool teachers (in kindergartens). In business women are represented in trade, outfit design, confectionery, services. Lack of jobs is the only obstacle to women's activity. Access to higher education depends on distance between place of residence and higher education entity location, affordable university fee and gender-related stereotypes in the family.

High education cost is the main reason for which girls are not proceeding to universities and institutes. Russian and English, music, physics, maths, chemistry teachers as well as doctors and psychologist lack in observed regions. Lack of jobs is the main cause of high unemployment rate among girls. But, women account just for 1% of labor migrants to Kazakhstan and Russia, most of them 30-40 years old. Large-scaled engagement of women in entrepreneurship, participation in life-long learning system, including studies in higher education entities is advised to boost women's economic activity locally.

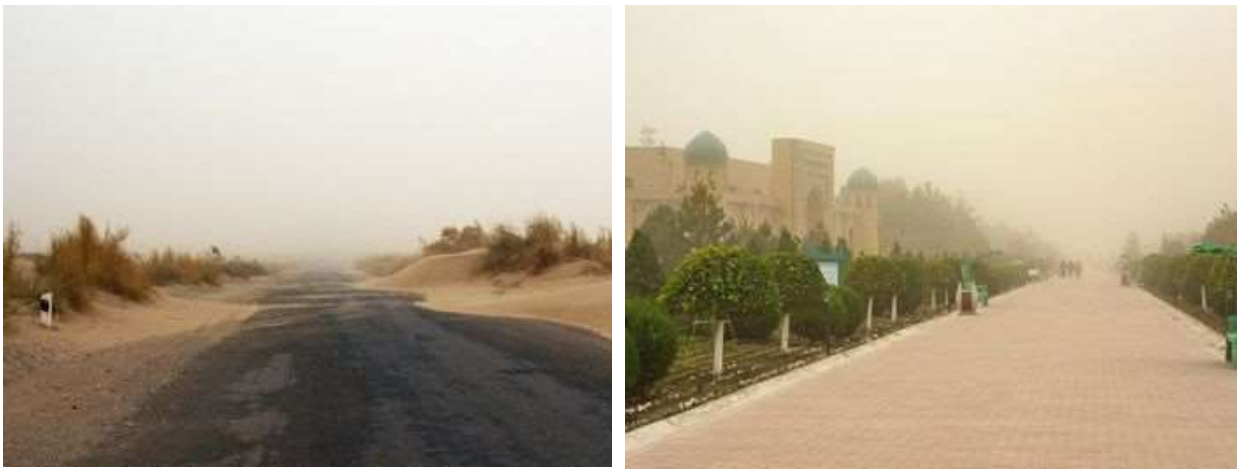
1.4. Methodologies of research on drifting sands and aeolation protection of operated and designed engineering facilities in Uzbekistan

Drifting sands and aeolations pose significant threat to agriculture, forestry, motor and rail road and other transportation and logistics systems everywhere in the world. Problems are especially severe in desert regions where land surface is covered with dry open texture sands, precipitations are rare and vegetation is almost lacking. Efforts to limit damage incurred by sand aeolation has long lasting history.

Wind impact moves unfixed sands. By its character sands particles movement is similar to the movement of snowflakes transported with snowstorm. Minor whirlwinds formed in wind current result in pressure drop causing upward inflow of sand grains. Bigger, heavier sand grains can not raise above in the air, and are just sliding and rolling, jumping above and falling down. Finest sand grains and dust move suspended in the air.

Due to sand pouring from the top into downwind slope barkhans are slowly moving with the wind. Higher you barkhan, longer slope it has where sand is moving on. Therefore, with the same speed of sand grains movement higher barkhans are moving at a slower pace comparing to lower ones. The central part of barkhan is always higher than its edges (so called «horns»). Thus, while moving «horns» are ahead of the central part explaining why barkhans are taking a shape of a crescent.

Barkhan movement speed depends on wind speed also. Speed of barkhan shifting fluctuates from tens of centimeters to hundreds of meters a year.



Picture 4. Dust storms in Termez city

It is well known that in desert environment all the elements of railroad are worn out at fast pace causing deflection of rail geometry. Dirting ballast shoulders with drifting sands causes sand heaves formation, deflecting track plans and profiles, resulting in increased expenses of operation and frequent replacement of superstructures as well as decrease of trains movement speed.

Labile forms of relief within the protective belt have to be firmly fixed to prevent drifting sands on motor and railroads, while the borne sands have to be held in the dark reaches to the road, i.e. at the beginning of protective belt and partially within it.

Zones of sand aeolation or blow out (deflation), transfer (transit) and gathering (accumulation) are distinguished both in all the complex ofsand deserts relief and within each of its elements.

Lower part of the windward slope of a certain barkhan is a zone of aeolation, upper part - transfer zone, and downwind slope is an accumulation zone. Barkhan moves as result of sand transfer from aeolation zone to accumulation zone with subsequent shifting zones with the wind.

Mechanical protection made of different material or live protection created by linear or strip planting are used to fix sand at the far reaches to the road.

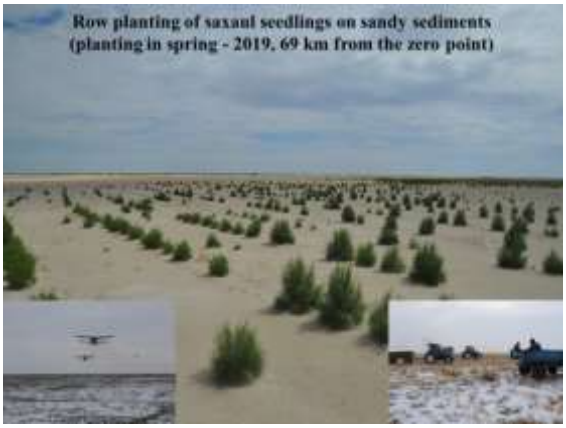
Sand fixing is made as follows:

- on both sides of the road if its axis matches sand movement direction or has angle with it by 30° as well as under variable winds;
- only from the prevailing wind direction side, when sands have clear onward motion with the 30° angle to road axis and sand drifting from the opposite side of the road is impossible.

Major portion of a sand (90 %) is located in lower

5-10 cm high layer of a wind and sands current. When wind and sand current encounters with mechanical protection sand settles down. Hence, rampart is emerges alongside protection belt. As sand accumulates mechanical protection shall be installed in new location standing away from the previous location at a distance 5-10 times exceeding rampart height. In the event of live protection belt rampart emerged is naturally ramped.

Vegetation planting is the most reliable way to fix the sands. The seeds shall be kept on fixation area until they sprout, and further after a year aeolation from root layer have to be prevented to ensure growth of sand-fixing plants in drifting sands. For this, sands are fixed temporary (surface fixation) with liquid binding substance (fixture).



Picture 5. Sand binding with plants

Fixing sands with vegetation on wide area adjacent to the road is reliable way to prevent from drifting sands for a long time. Noteworthy, this National Action Plan contains detailed recommendations on improvement of laws and regulation on growing protective forest vegetation to prevent SDS on dried-up Aral Sea bed as well as growing and recovering protective forest plants to combat wind-induced erosion on irrigated lands and sanding of water facilities.

1.5. Plants selection as per the types of habitat conditions

Uzbekistan is the most abundant in flora part of the Central Asia. Natural vegetation cover in the country consists of over 4000 types of plants, namely vast majority of valuable plants, such as edibles, fodder plant, herbs, tannin plant, saponin-bearing plants, essential oil plants, dye plants, ornamental plants and etc., including rare old-growth plants, endemic plants. Vast floristic and coenotic diversity is determined by heterogeneous environmental conditions (especially, as far as climate is concerned) in vertical belts with various hydrothermic modes. Alongside with this, due to specific soil conditions each belt has heterogeneous habitat. Following belt-based regularity of vegetation spread four belts can be distinguished within the territory of Uzbekistan, such as chul (deserts); adyr, tau (mountaineous), yaylau (grazings) corresponding to geomorphologic stages of plain terrains (deserts), piedmonts, mountains, highlands. Common landscape, relief, hydrothermic conditions as well as vegetation and soils succession from area to area are the main tool to distinguish these vertical belts.

Representatives of various forms of plants life, namely trees, shrubs, low shrubs, semi-shrubs, grass plants with different vegetation cycle take part in forming plant complex of these belts. Mountains zone account for above 70 % of all tree species. Some of them form the major stands of the country's mountain forest, while the others are the cornerstone for tugai (riparian) woodlands. Sand plain terrains account for around 10% of species of trees from leafless plants (white saxaul) and leaf succulents boughs (Salsola Richteri Karel) groups. Almost all the species of these groups play edificatory part and form specific landscapes on vast areas. Majority of species of shrub form prevail in plain terrains, especially in sandy habitats. Phyllade shrubs with (species genum: Calligonum, Ephedra) prevail in this area.

Vast majority of species from shrub vegetation form is spread in piedmonts and mountains, especially on south slopes of granitic and crush stone or gypsified areas of cameo hills. Polster-type shrubs are peculiar to conditions of Uzbekistan. These are the typical representatives of open type granitic and crush stone slopes, watersheds of mountaineous and highland belts of arid zone.

Most of the representatives of this form (prickly thrift, Acantholimon genum species, Onobrychis echidna Lipsky) are edificators for the whole phytocoenosis group of highland xerophytiums. Group of leaf succulents and stem succulents' forms of low shrubs is minor, though most of them (Kalidium caspicum, Aellenia subaphylla, Halocnémum) are the edificators for Salsola plants. Minor semi-shrub group of regular type can be encountered in mountains and piedmonts. Typical succulent forms peculiar to desert habitats (for instance, Aellenia subaphylla var. typica) can also be observed in this group. Semi-shrubs are the most numerous group among the mentioned vegetation forms. The largest diversity of species is registered in mountaineous zone (the smallest one is in highlands). However, they dominate in plain terrains as landscape plants on vast areas and edificators for gypsum and salt marsh desert formations. So, for instance, Artemisia genum species prevail on vast areas of gypsum surfaces of cameo mountains, sand plain terrains, lowlands' crushed stone descents. Grassy form gained leading position among flora of Uzbekistan. This type has the biggest number of species and diversity of forms. Majority of species are encountered in mountaineous belt.

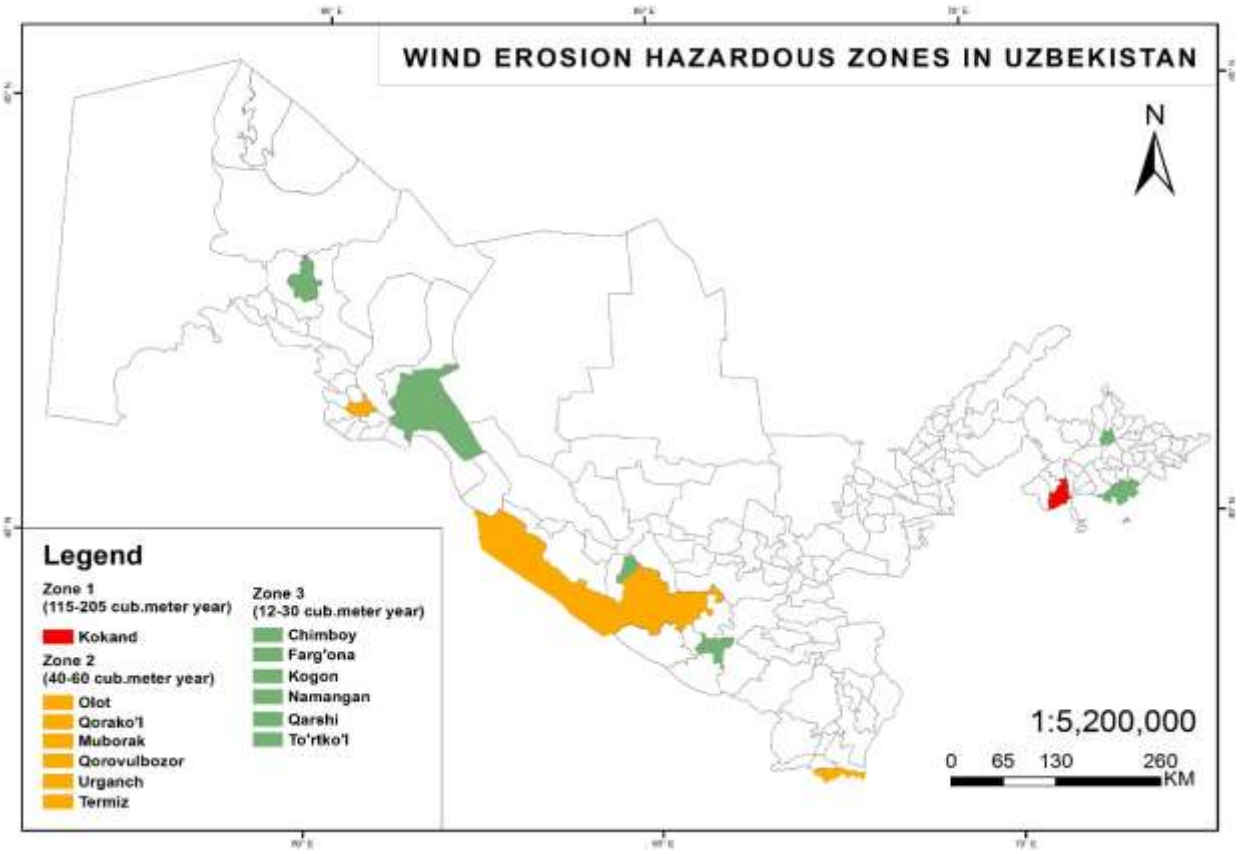
2. SAND AND DUST TRANSFER AND ACCUMULATION PROCESSES DEVELOPMENT

2.1. Wind conditions in the SDS development area

Dust storm is wind-induced erosion (deflation) or, in other words, destruction and transfer of topsoil under wind speed range 12-15 m/s. From outside it looks like wall made of dust and sand is approaching. Depending on region and soil composition it can come in different colors:

- Black (rich black soil);
- Yellow and dark (loam and sandy loam);
- White (salt marsh);
- Red (red soils of Iran and Afghanistan).

Though dust storms mostly emerge in summer, if there is no precipitation and ground is drying up fast they can happen even in spring. Regions with the highest wind-induced erosion hazard in Uzbekistan are Kokand, Kulkuduk, Jaugeldy cities (first zone) with possibly transferable barkhans volume totaling 115-205 m3 a year; second zone covers Karaul Bazar, Mubarek, Alat, Karakul districts of Bukhara province as well as Urgench city of Khorezm province, Termed city of Surkhandarya province were possibly transferable volume is estimated at 40-60 m3 a year and the third zone covers Karshi, Chimbay, Kagan, Ferghana, Namangan, Turtkul with this volume accounts for 12 to 30 m3 a year. Barkhan sands movement speed in these areas range is 14-20, 8-15 and 4-5 m a year respectively.



Picture 6. Hazardous wind-induced erosion zones in Uzbekistan

Dust storms, wind-induced topsoil removal from the surface of irrigated soils as well as shifting intraoasis and oasis-side sands of Central Ferghana, Karakalpakstan, Surkhandarya cause significant damage.

Dust storms are the complex issue for Aral Sea region, especially after denudation of the major part of a sea bed. Average annual number of dust storm days here is comparable to those even on remotely located desert area [Picture 9].

Since spring 1975 pictures taken from artificial satellite enabled to register vast sand and dust exports from the east coast of Aral Sea. Dust plumes covered even Karak and Chirik-rabat districts. In 1979 vast dust export to Ustyurt plateau extended 250 km from the west coast of Aral Sea. 1,5 to 3 mln. tones of salt-containing dust may fall on area of Amudarya delta in one export session. In cities located in southern part of Aral Sea while dust storms hazardous substances content is registered to exceed single-time MACs ten times. Simulation model based calculations show that aeolian transfers in dried up part of a sea bed and water zone reach 120 mln. tones a year with the export distance extending for over 500 km.

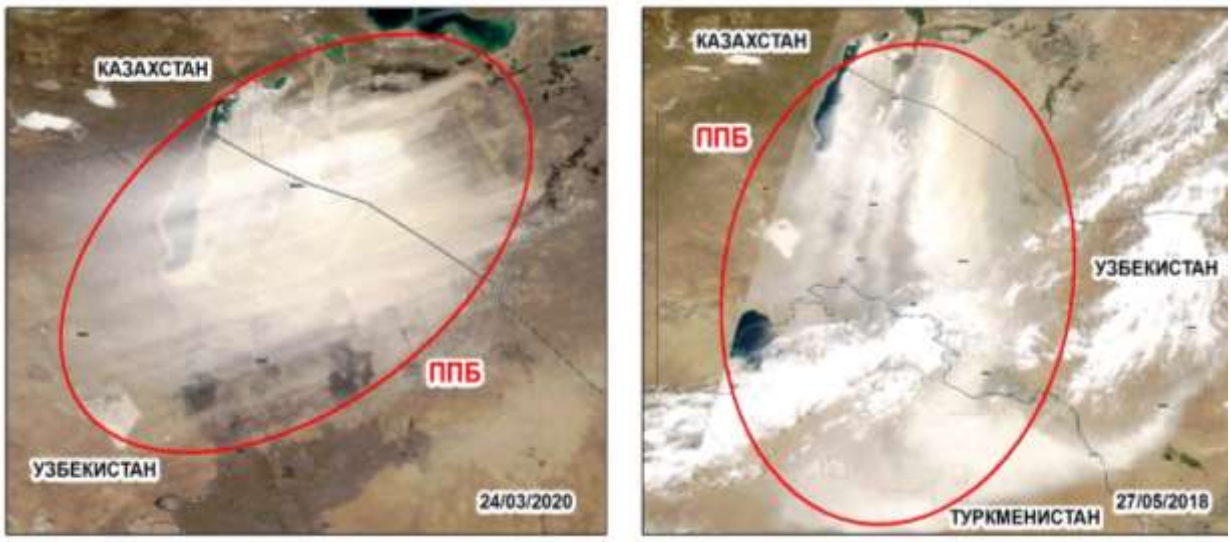
Climate scenarios simulating realistic options of climate parameters set change as a response to major anthropogenic climate-impacting factors (various green house gases and aerosols atmospheric concentrations changes, land use changes and etc.) change are used for assessment of climate change impact both globally and regionally.

Pollution impact is worsened due to the fact that Aral Sea is situated on the route of powerful air stream heading from the West to the East facilititating aerosols transfer to the higher layers of atmosphere. Traces of salt streams can be tracked all across Europe and even in Arctic Ocean. However, winds of eastern bearings can also be observed in this area. Relevant dust storms are shown in Picture 7. Such dust storms transfer huge amount of sand and dust to the sea. Moreover, they raise water level on the east coast in western part of Aral Sea. Consequences of Aral Sea disaster have overstepped regional boundaries of Central Asia. Over 100 thousands tones of salts

and fine dust mixed with various chemicals and poisons are exported annually from dried-up sea area affecting all living organisms. Agricultural drains from local fields caused pesticides and other agricultural poisonous chemicals spread in the area of up to 54 thousands km² of dried up sea bed covered with salts. Dust storms transfer salts, dust and poisonous chemicals to distances of 500 km.

Sodium bicarbonate, sodium chloride and sulfate are transported with the air destroying or significantly hindering growth of natural vegetation and different agricultural crops.

With the regard to dust storms occurring together with drifting dusts some regions where dust and sand are transfered more intensively on ground level can be distinguished among others. So, in 1991-2000 in Muynak dust storms and drifting dusts number (21 days) is 7 times bigger than that of dust storms only (3 days), at Karakalpakiya observation station corresponding numbers total 51 and 10 days respectively. Similar ratios can be seen across the majority of other observation points. Annual cycle of dust storms peak in warm seasons (from April to August).

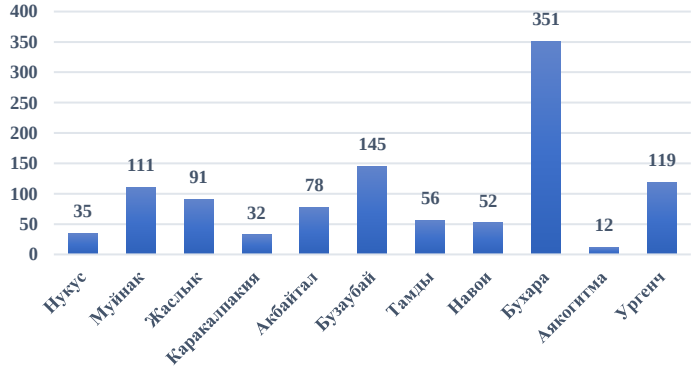


Picture 7. Sand storms above Aral Sea according to the Earth Remote Sensing Aqua-MODIS [9]

Picture 8. “Afghani” Sand storm according to the Earth Remote Sensing Aqua-MODIS [9]

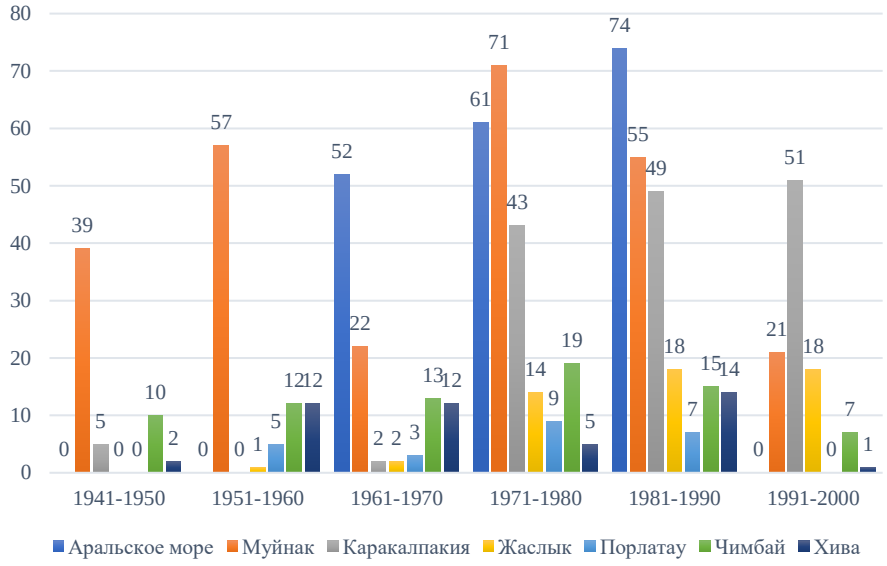
Southern regions of Uzbekistan have another specific severe weather phenomena - «Afghani» wind coming from the territory of Afghanistan. Afghani wind emerges in the eastern margins of

Karakum desert and with huge speed of 20 m per second heads to Pamir mountains piedmont. This wind emerges as an outcome of regular invasion of cold front into hot Baktrian plain terrain. The impact of Aghani wind would not be so significant if it would not have been raising tonnes of sand and dust which further move to Termez city, falling on residential settlements and farming fields. It damages harvests, destroys topsoils, and, definitely, produces adverse impact on health of local



Picture 10. Average annual number of Sand storms and low drifting dusts days in various decades between 2010 and 2019

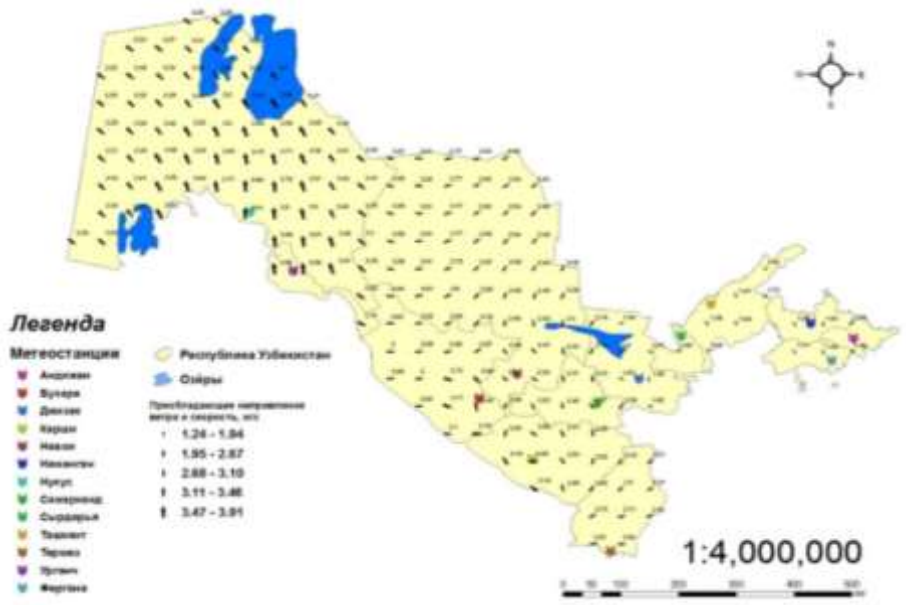
residents. In Termez city it can be observed up to 70 days a year, and, noteworthy, in all the seasons, no matter whether it is spring, summer, autumn or even winter. Sometimes it blows for several hours, or even several days. It may also come along with precipitation and cold snap, sometimes.



Picture 9. Average annual number of Sand storms and low drifting dusts days in various decades between 1941 and 2000

Dust storms lasting for less than 5 hours have the biggest frequency of occurence. Often dust storms of this duration can be observed in March. While dust storms and shifting dust northern, north-eastern, eastern and southern-eastern winds prevail on the others: frequency of occurrence

is twice as of these of two other air stream directions. Winds with speed of 10-14 m/s on surface level occur most frequently, while those with the speed exceeding 15 m/s are the less frequently occuring ones, especially under north-western and western winds facilitating dust export to the territory of Uzbekistan (Picture 11).



Picture 11. Average annual speed (m per sec) and direction according to weather stations in the Republic of Uzbekistan in 1971-1999 [6]

Picture 12. Average annual speed (m per sec) and direction according to weather stations in arid areas in the Republic of Uzbekistan in 2000-2019

According to the data by the Ministry of Agriculture, the vast area of irrigation zone in Uzbekistan is exposed to wind-induced erosion. The major centers of wind-induced erosion occurence are Central Ferghana, Dalverzin, Mirzachul, Karshi, Sherabad steppes and Bukhara oasis. The most productive layer of topsoil was removed as a result of continuous wind operation with topsoil structure in wind operation centers became more vulnerable to mechanical changes. Eroded soils

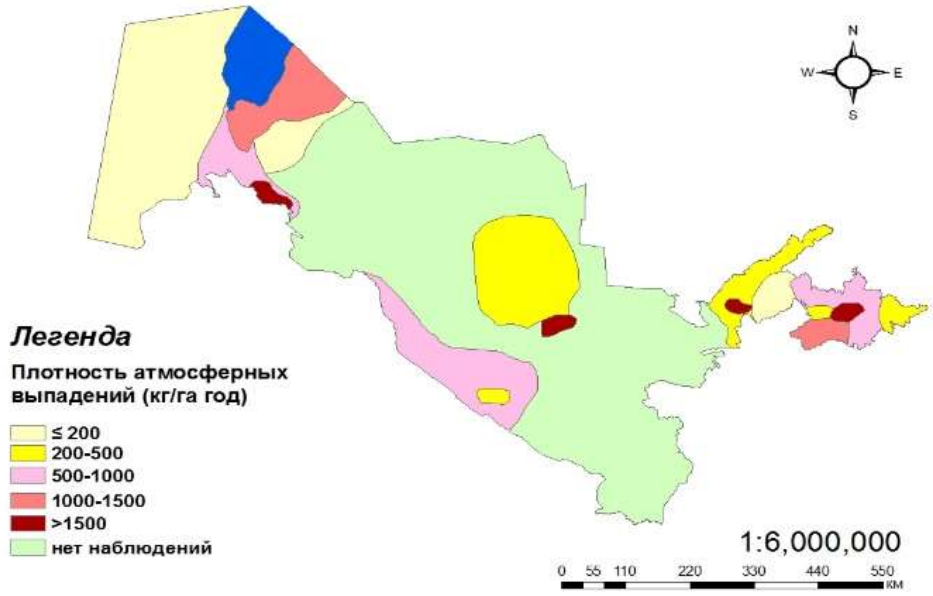
lack nutritive components resulting in abscission of buds, flowers, sets and even cases of agricultural crops[2].

In general, wind conditions in Uzbekistan can be viewed as those facilitating SDS process. According to climate change experts forecasts, alongside with average temperature increase global warming will result in growing possibility of extreme phenomena occurence. Droughts, severe thaws, frosts, heavy precipitation and mudflows as well as SDS are the cataclysms peculiar to Uzbekistan to larger extent.

2.2. Sand and dust transfer and accumulation in SDS development areas

Dust consists of solid particles (SP) with size distribution and structure composition is determined by their origin (natural or anthropogenic). Dust can be made of mineral salts, metal oxides and organic compounds.

These processes gain especially prominence in dried-up Aral Sea bed intensifying dust transfer and creating within short period of time several accumulated and denudated aeolian forms of relief depending on density of bedding rocks, relief fairness, district's wind conditions, surface fixity. Transformation of surface of alluvial, deltaic and sea plain terrains made of sand begins with deflation pits further growing to basins. Basins with sharp slopes are currently at the stage of active development. Lack of sharp slopes proves deflation attenuation. And, vice versa, ripple marks emerging on open surfaces indicate on deepening deflation. If all the positive forms of relief become movable and vegetation cannot fix on them major deflation processes are underway.



Picture 13. Density chart and map of dry atmospheric precipitation flow within the territory of Uzbekistan

Cumulative capacity of anthropogenic sources of solid particles emission to the atmosphere is significantly higher comparing to natural ones, and us estimated at 1,311 mln. t/year. Solid particles share in anthropogenic emissions is low accounting for 16% in case of industrial sources and 2 % for moving sources.

Solid dust particles falling on bed rocks due gravity impact are called dry atmospheric fallouts (DAF). Density of particles stream falling from the atmosphere to unit of surface within unit of time (kg/ha a year) is used as quantity parameter to evaluate dustiness of atmosphere.

[2] https://agro.uz/ru/services/recommendations/4529/

2.3. Forest growth conditions in the regions of possible development of SDS

According to the criteria of UN World Atlas of Desertification and UN Convention to Combat Desertification, the territory of the Republic of Uzbekistan with aridity indicator values ranging from 0,03 to 0,20 is totally located in arid region exposed to intensive desertification.[https://knowledge.unccd.int/sites/default/files/naps/uzbekistan-rus1999.pdf] Most part of the country stretching from north-west to south-east made of plain terrains is occupied with deserts while south-eastern part consists of piedmonts and mountains.

Winds of northern bearings prevail in the territory of the country. On north these are the winds with northern-eastern direction, replaced with winds of eastern, further south-eastern direction as we move southward. Wintertime this can be explained with the impact of Asian anticyclone while in summer - with low pressure centers based in the South of Central Asia and north-west of India. Sand and dust storms occur in hot summer season in the central and south-western parts of the country. In mountainous regions wind direction depends on relief. Local winds, such as mountain-valley winds and foehns blow here. Bekabad wind blows from Ferghana Valley to Yashrzagul, while Kokand wind has opposite direction. Dry south-western wind called «garmsil» is peculiar to the south of the country. On the south of Surkhandarya province hot and dry south-western wind called «Afghani» brings dust and sand on its way. In Termez city area dust raised by the wind clouds the sky. Springtime this wind affects blooming trees, young shoots of cotton and vegetables.

Average annual speed of wind is relatively low.

On the plain terrains it ranges within 3-4 m/s, in piedmonts and mountains slightly reaches 3 m/s. Major feature is a big number of windless days, exceeding in certain regions over half of year. However, increase of wind up to 6-10 m/s together with fast soil drying peculiar to desert area of the country facilitate emergence of SDS. Average annual number of dust storm days depends on local natural conditions and ranges from 10 to 30 days on the most part of plain terrains area, while in some regions (such as Karshi steppe, lower reaches of Amudarya) it can reach 50 days or even 64 days as in Muynak. Vegetation period (temperature over 10°C) lasts from 190 days on the north to 240 days on the south. Vegetation period degree days range from 19°C on the north to 27°C on the south (Surkhandarya river basin).

Desert sand soils and sands prevail on vast areas of Kyzylkum desert. Relatively small areas with desert sand soils and sands can also be encountered in Karshi steppe, lower reaches of Kashkadarya and the center of Ferghana valley. Sandy soils are peculiar to regions located 400-500 m above sea, occupying 70 % of country's area. Grey-brown, sandy, takyr soils and sierozems can be met in deserts. Due to the strong heat soil substances decay and mineralize at fast pace. Therefore, humus content in soil is so small. Grey-brown soils are wide spread at Ustyurt plateau, Kyzyklum lowlands, Nuratau piedmonts. They have minor humus content (0,3-1,0 %), and are mostly subsaline with rare vegetation. Mostly small cattle are grazed there. Sandy soils with 0,3-0,6 % humus content is wide spread on sand plain terrains in Kyzylkum desert, Zarafshan lower reaches, central Ferghana and Mirzachul, and vegetation is lacking.

Desert takyr soils and takyrs are peculiar to ancient dried-up river-deltas as well as dried-up lacustrine plains. They are mostly spread in southern part of Aral Sea, lower reaches of Zarafshan and Kashkadarya as well as Assake-Audan depression of Ustyurt Plateau. Salt marshes, playing significant part in structure of deserts' soil cover, are mostly related to drainless depressions. Wet salt marshes of Barsa-Kelmes depression of Ustyurt Plateau, Mollaly, Karakat and others in Kyzylkum desert refer to this type. Last three decades area of salinified soils and salt marshes expands in Amudarya river delta as well as in the territory of dried-up Aral Sea bed.

2.4. Earth-based observation monitoring and assessment of SDS processes scale the framework of overall development of desertification processes

Land resources use, soil quality and factors impacting their condition are measured and relevant data are collected and processed in the framework of existing national system of Earth-based monitoring. For instance, Uzhydromet watches over soil pollution with pesticides, heavy metals, hydrometeorological and agricultural meteorologic parameters and etc., Ministry of Agriculture monitors land use structure changes, quality of irrigated lands (bonitet), grazing degression, performing also natural grazing vegetation monitoring. Ministry of Water Resources observes use of fertilizers, productivity and water consumption. However, this information should be cautiously used to assess desertification and land degradation processes after preliminary analysis, reliability evaluation and identification of uncertainties.

However, by now there is no state monitoring system available, and desertification processes assessment is episodic, undertaken in the framework of grants of SCSC and internationally-funded projects. Nationwide monitoring is performed by eight ministries and entities, each of them is charged with certain duties (Table 1).

Table 1. Ministries and entities in charge for sectoral monitoring

Entity	Type of monitoring
State Committee on Ecology and Environment Protection	Monitoring of atmospheric air, surface water and soils pollution sources (emissions) as well as flora and fauna monitoring in preserved areas operated by the State Committee on Ecology and Environment Protection
Uzhydromet	Monitoring of atmosphere pollution, surface (natural watercourse) water, soils, baseline monitoring; Climate change and natural environment pollution monitoring in the Republic of Uzbekistan (according to the Resolution of the President No. PP-4896 dated November 17th, 2020, item 2)
Ministry of Water Resources	Monitoring of composition of collector and drainage water from main collectors and meliorative wells
State Committee on Geology and Mineral Resources	Monitoring of ground water pollution and hazardous geological processes
Ministry of Healthcare	Environmental health monitoring
Ministry of Emergency Situations	Monitoring of radiation and biological emergencies across the country
State Committee on Forests	Monitoring on degradation and desertification as well as forestry flora and fauna and other facilities monitoring in the lands managed by the State Committee on Forests
Ministry of Agriculture	Agricultural lands monitoring as well as natural grazing plants monitoring

At present a lot of reports are available on various parameters to identify land degradation degree, but the assessments are discrete and mechanism is lacking for comprehensive analysis of desertification processes, thus, desertification monitoring system related issues need to be solved.

Data on land degradation and desertification processes path is of extreme importance for:

a) desertification processes diagnostics for a certain area;
b) land use conditions analysis and assessment as well as identification of economic risk zones in all the levels of economic activity;
c) actions or decision-making aimed at:
    - optimization of area land use to limit land degradation;

- ensuring introduction of resources-saving land use technologies;
- rational planning and location of farm on landscape and economic as well as legal basis;
- efficient use of allowed lands;
- enhancing saving and rational utilization approach while withdrawing land for non-agricultural purposes.

3. RELIEF AND CURRENT AEOLATION PROCESSES IN UZBEKISTAN

3.1. Soil and vegetation cover degradation impact on SDS emergence and development hazard

Land degradation due to erosion, pollution, deforestation and salinification plays crucial part in emergence of possible SDS sources due to both natural, climate-related and anthropogenic, human activity-induced factors. Major climate-related indicators, mechanical composition of covering deposits, soil-forming and bed rocks initial salinification degree pave the way for natural soil degradation. Salinification, bogging, overgrazing, irrigation-induced erosion, tree and shrub vegetation cut, man-made burden and etc. refer to anthropogenic land degradation factors. Conditions of over 400 thousand ha, i.e., above 10% of irrigated lands are estimated to be unsatisfying.

Significant part of land resources is exposed to vegetative cover degradation, sands deflation, water and wind-induced erosion, salinification of irrigated soils, man-induced desertification, soils pollution cause by people's economic activity. Consequences of such change in soils quality can be reflected in quantitative and qualitative decrease in texture and viscosity features, reduction of natural and economic importance.

In Uzbekistan salinized lands totals 45,3 % of irrigated area, including slightly salinized - 31,1 %, moderately salinized - 12,2 %, and heavily salinized - 2,0 %; 24,4 % of ground water area are located at least 2 m above sea. Recently, due to water shortages observed, poor meliorative conditions of land, delayed administrative remedy actions 560 thousand of irrigated lands are slightly provided with water, 298,5 thousands of ha of irrigated lands were withdrawn from operation[3].

Around 15,1 mln. ha of land are not used in farming (slopes, slide rocks, landfills, sands, waste dumps and etc.). Over 160 thousands of ha are exposed to man-induced impact.

In Uzbekistan grazings occupy 21,2 mln.ha, or almost half of the territory, including 14,4 mln.ha – desert, 5,7 mln.ha – piedmonts, 1,1 mln.ha – mountaineous and highland-located ones. Mainly, grazings, are located in the Republic of Karakalpakstan, Bukhara, Navoi, Jizzakh, Surkhandarya and Kashkadarya provinces. Approximately 19,4 mln.ha of grazings are flooded, 2,8 mln.ha - require watering. 16,4 mln. ha (77,3 %) of grazings are exposed to degression, clearly seen in Karakalpakstan, Navoi, Bukhara and, Surkhandarya provinces. With the regard to period of operation grazings are divided into: summertime grazings - 5,4 mln.ha, wintertime grazings - 3,8 mln.ha, year-around grazings - 3,5 mln.ha.

In Kyzylkums most of them area is occupied with low-production and degraded grazings. Currently, vast areas adjacent to wells and residential settlements are degrading due to utilization of plants for fuel, resulting in area desertification, worsening problems with SDS.

Depending on weather conditions in certain years number of vegetation species actively growing on desert grazings ranges from 9 to 55, while productivity is around 2 to 9 c/ha. Average

[3] Decree of the President of the Republic of Uzbekistan No. UP-6024 «On approval of the Concept of Water Management in the Republic of Uzbekistan for 2020-2030» dated July 10th, 2020.

productivity of grazings, according to calculations made by different entities, totals 2,4-2,7 c/ha. Low production year happens once in every five years one year, while for two years moderate productivity and for two years high productivity rates are observed. In such circumstances, insurent fodder reserve have to be made and vegetative species composition improved be improved with shrubs and semi- shrubs planting. Bukhara and Navoi province account for 22% of country's sheeps and 60,8% - of camels, mainly feeded with desert vegetation.

4. NATIONAL STRATEGIES AND PRIORITIES AIMED AT SDS MANAGEMENT

4.1. Systemic and institutional framework facilitating SDS management and adverse impact mitigation

Strategic sustainable development goals of the Republic of Uzbekistan include ensuring healthy and productive life of each and every citizen, improving ecological situation, overcoming consequences of Aral Sea disaster, nationalisation and efficient use of land, water and other natural resources as well as combating desertification and sustainable development of environment. Therefore, development of systemic and institutional framework facilitating SDS management and mitigating its adverse impact is one of the strategic directions of the country's development. Considering strong links between SDS and desertification, drought, natural resources protection, whole range of legal acts were approved in the Republic of Uzbekistan, international conventions regulating ecological relations in the country were ratified.

Currently regulatory acts fostering SDS management and its adverse impact mitigation in the Republic of Uzbekistan include Laws of the Republic of Uzbekistan «On protection of a nature», «On water and use of water», «On protection of atmospheric air», «On waste», «On protection and use of flora», «On protected natural areas», «On protection of population against natural and man-induced emergency situations» and «On civil protection». These laws regulate issues of natural resources protection, preservation and use with emphasis on vulnerable environmental components ensuring critical interests of an individual, society and the state.

A whole range of Decrees of the President (PD) and Resolutions of the Cabinet of Ministers (RCM) of the Republic of Uzbekistan was approved to regulate these issues, namely: PD №4850 dated October 6th, 2019 «On approving the Concept of Forestry Developments in the Republic of Uzbekistan by 2030» [30], PD №4204 dated February 22nd, 2019 «On the measures to improve efficiency of desertification and drought combat in the Republic of Uzbekistan» [19], PD №4424 dated August 23rd, 2019 «On supplementary measures to improve efficiency of forest use in Uzbekistan» [21], RCM №199 dated May 1st, 2003 «On improving system of payments for environment pollution and waste disposal in the territory of the Republic of Uzbekistan» [14], RCM №15 dated February 6th, 2006 «On improving system of payments for special-purpose nature use» [15], RCM №11 dated February 3rd, 2010г. «On supplementary measures to improve environment protection activities within housing system» [16], as well as RCM №820 dated October 11th, 2018г. «On the measure to further improve economic mechanisms to ensure environment protection», based on which «Regulation on the procedure of application of compensation payments for environment pollution and waste disposal within the territory of the Republic of Uzbekistan» [17] was approved.

Considering its mandate and experience in SDS related processes, the project envisages to engage following ministries and entities to implement National Action Plan on SDS prevention and mitigation of its consequences in Uzbekistan: State Committee on Forestry (Forestry Committee), Ministry of Emergency Situations (MES), Centre of Hydrometeorological Service (Uzhydromet), Ministry of Agriculture (Agriculture Ministry), Ministry of Healthcare (Health Ministry), Ministry of Water Resources (Water Ministry), State Committee on Ecology and Environmental Protection

(Ecology Committee), Committee for the Development of Sericulture and Karakul Farming, Association of Grazing Users and etc.

Forestry Committee shall be the entity in charge of SDS NAP implementation, on the behalf of the Government of the Republic of Uzbekistan currently proactively involved in international efforts on UNCCD on national and local levels. According to the PD «On the measures to improve efficiency of desertification and drought combat in the Republic of Uzbekistan» following additional functions were granted to the Forestry Committee [19]:

- implementation of measures to prevent desertification, forest recovery and protective forestry in the country;
- fulfilling international obligations of the Republic of Uzbekistan to combat desertification and drought;
- ensure efficient interaction with international and regional organizations in the domain of desertification and drought combat;
- coordination of activities of ministries, entities and lical executive authorities engaged in elaboration and implementation of programs and projects aimed at desertification and drought combat in the Republic of Uzbekistan;
- executing the mission of authorized national body of the Republic of Uzbekistan in the framework of fulfilling the requirements of the UN Convention to Combat Desertification and Drought.

National development priorities include agricultural and water resources policy based on sustainable mechanisms of coordination and encharged entities interaction, priority actions to combat desertification, drought and SDS as well as ensuring preparedness and coordinated activities of the concerned parties. Periodic government development plans include activities to prevent and mitigate adverse impact of drought and SDS, sustained water demand from society and economy's side.

According to the RCM «On further improvement of the State system on emergency situations warning and actions in the Republic of Uzbekistan» [20], State System of Prevention and Response to Emergency Situations (RSChS) is operated in Uzbekistan, joining management authorities, forces and funds of central and local authorities, enterprises and institutions mandated to arrange response to emergencies. The system consists of the following ministries and entities: MES, Uzhydromet, Ministries of Heathcare, Agriculture, Water Resources, Ecology Committee with functions of each institution clearly defined. RSChS activities must be based on Uzhydromet estimates and forecasts, including those on SDS.

RSChS consists of regional and functional subsystems of three levels, namely national, local and facility-related one. Emergency situations in Uzbekistan include, but not limited to:

- Threat of agricultural and meteorological drought, causing lack of moist in the atmosphere and resulting in plants water imbalance, their oppression and possible death with significant material loss.
- Threat of hot dry wind (air temperaturexceeding ng+45°C, strong wind and air humidity up to 30 % occuring for at least 5 days in row), causing significant material losses by oppressing and killing agricultural plantings and posing a challenge to people's health.
- Threat of lack of water and water resources shortage, which may possibly cause disturbance of people's activity and significant economic damage to agriculture and certain branches of the economy.
- Threat of strong heat (air temperature above +40°C for several days) causing significant economic damages while affecting agricultural plantings and challenging people's health. In some cases it poses threat to regular performance of certain branches of the economy.

Unfortunate, nowadays SDS are not included in the list of emergency situations in Uzbekistan.

RSChS executes following key tasks:

- execution of government policy, elaboration and implementation of of laws and regulations in the field of population and regions protection from emergencies in time of peace and war;
- prediction of possible emergencies across the country, assessment of their social and economic impact;
- elaboration and implementation of the special-purpose and comprehensive scientific and technical programs aimed at emergencies prevention, ensuring people's safety, hazardous technology and manufacturing risks reduction, enhancing sustainable performance of the branches of economy, other institutions;
- ensuring of permanent preparedness of management authorities, forces and funds for emergencies prevention and mitigation;
- collecting, processing, exchange and provision of information on population and regions protection from emergencies;
- training population, officials from management authorities, forces and funds of RSChS to act in emergencies.

Note, currently the Republic of Uzbekistan has no special legal act clearly emphasizing on sand and dust storms and governing actions and measures to manage their adverse consequences. Effective legislation has only indirect indications on SDS as natural or natural and anthropogenic phenomena, which can result in destruction of material assets and components of environment. Particularly, PD «On the measures to improve efficiency of desertification and drought combat in the Republic of Uzbekistan» has indication on impact of drifting sands and dust storms on aridity of certain areas, and PD «On approving the Concept of Forestry Developments in the Republic of Uzbekistan by 2030» suggests introduction of innovative technologies to combat dust and sand storms in order to restore and improve environmental balance in Aral Sea region. According to RCM «On classification of emergency situations of man-induced, natural and ecological essence» dated October 27th, 1998 [24], sand and dust storms are not listed as emergency situations of man-induced, natural and ecological essence. Therefore, lack of legal recognition of SDS as disasters and emergency situations hinders development of systemic and institutional framework facilitating SDS management and mitigation its adverse impact.

This project envisaged to table to consideration of the Government of the Republic of Uzbekistan a proposal to approve special regulatory act, establishing legal and institutional framework to recognize SDS as emergencies and governing SDS prediction and prevention related issues in the country. Considering that laws and regulatory acts concerning sand and dust storms related processes require review and update as per the today's requirements, survey of effective legal acts to identify challenging documents hindering activities on SDS management is deemed feasible.

Noteworthy, the country lacks centralized system of SDS monitoring and consequences assessment. Most of entities in charge lack data on SDS and its consequences even within the scope of their competency. SDS and consequences related information of public domain can be found only in independent media; for instance, news agency www.gazeta.uz timely reported on dust and sand storms emerged in Karakalpakstan and Khorezm on May 27th, 2018.

According to the official letter of the State Committee on land resources, geodesy, cartography and state cadastre (previous operated entity, its functions concerning land resources were transfered to the Ministry of Agriculture) №03-04-5988 dated June 24th, 2020, the Committee reports that it lacks information on river basins, water reservoirs and minor irrigation systems in arid regions as well as regions suffered from sand and dust storms.

According to the official letter of Uzhydromet №01-15/309 dated May 18th, 2020, Uzhydromet informed that it has no data on regions suffered from sand and dust storm.

Agreement between Institute of Botanic and State Forestry of Moynak region dated March 2nd, 2020 was aimed at grazings inventory in State Forestry of Moynak region. Considering that main site of forestry is located in dried-up Aral Sea bed, based on remote sensing data classification of vegetation grew on dried-up bottom of Aral Sea (TSAVI) from 1970 to 2019 was developed in March - April, 2020, and connection between sea level drop and vegetation growth was revealed. According to the results of the research, natural-regional complexes were classified as those with very low, low, average and high level of biomass production. Trends of their development enable to identify areas within the dried-up sea bed that can possibly cause sand and dust storms, requiring urgent rehabilitation.

In 2017 the Republic of Uzbekistan implemented reforms in forestry system. According to the Presidential Decree №PD-5041 dated May 11th, 2017, the Main Department of Forestry under the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan was reorganized into the State Committee on Forestry of the Republic of Uzbekistan. To execute this decree, Resolution of the President of Uzbekistan №RP-2966 "On organization of activities of the State Committee of the Republic of Uzbekistan on Forestry" dated May 11th, 2017 was approved, and in accordance with the approved documents activities of forestries and their scope of work were reconsidered.

Prior to forestry reforms rate of forest landscapes recovery was negligible. Between 2011 and 2017 counter-erosion forest plants were planted on 45 thousand ha in average annually, of which v40 thousands ha were located in desert area, including 16-18 thousands ha were planted in dried-up Aral Sea bed. Forest landscape recovery in pedmont and mountaineous zones covered 2-3 thousands ha, while remaining 1-2 thousands ha were targeting riparian woodlands and valley zones.

Nowadays, over 2,5 mln. ha of dried-up Aral Sea bed require afforestation, with current forest planting rate of annual 16-18 thousands ha it would have taken over hundred years. Moreover, there are vast areas calling for afforestation in Kyzylkum desert. Vast abandoned areas in country's piedmont and mountaneous zone are mostly used by rural residents as cattle grazings.

Since 2018 dcope of work on forest landscape recovery increased tenfold, mostly due to jump in works performed in the dried-up Aral Sea bed as well as in connection with nut-bearing planting in piedmont and mountaneous zones. If, for instance, by 2018 forest planting in dried-up Aral Sea bottom totaled 16-18 thousands ha annually, in 2019 it jumped to 501 thousands ha, while in 2020 planting expanded to 700 thousands ha. Nut-bearing plantings in 2017 were made in 1,0 thousands ha, in 2018 – 3,0 thousands ha, in 2019 – 6,2 thousands ha, in 2020 it was scheduled to afforest 9,5 thousands ha. In general, from 2011 to 2020 forestry entities across the country recovered forest landscapes on over 1560 thousands ha.

4.2. Cooperation with international organization and partners in the field of SDS management

As UN member state Uzbekistan supported and approved 17 Sustainable Development Goals (SDG). The country undertakes systemic and targeted work to adjust global SDGs to country features and preparation of the state program on national SDGs implementation by 2030. The Republic of Uzbekistan is an member of of the following global environmental conventions: UN Framework Convention on Climate Change (UNFCCC), UN Convention to Combat Desertification, Land Degradation and Drought (UNCCDD), UN Convention on Biodiversity (UNCB), Paris Agreement, Ramsar Convention on Wetlands, Convention on the Conservation of Migratory Species of Wild Animals, Vienna and Monreal Protocols. According to obligations within their framework, plans and five year action plans on environment protection are regularly developed and approved as guideline documents.

New stage of country's development with transition to innovative development path is underway sincece 2017, aiming at drastic improvements in all domains of life of society and state. A whole range of essential Decrees and Resolutions of the President of the Republic of Uzbekistan and the

Cabinet of Ministers, Law «On grazings» (2018) was enacted, national programs and institutional reforms were launched aiming at fostering food security and sustainable long-term development.

UN multi-partner trust fund for human security for Aral Sea in Uzbekistan was established in November 27th, 2018 under aegis of UNDP in Uzbekistan. Special-purpose charity «Muynak-2019» foundation and other mechanisms we're created to foster urgent actions on mitigation desertification, drought and SDS impacts in ecological disaster area.

In the framework of this initiative Atlas was developed based on social and economic research conducted by the Institute of Social Research in partnership with UNDP. Atlas is a review of social and economic situation in eight regions of the Republic of Karakalpakstan exposed to Aral Sea disaster the most. It reflects various aspects of people's wellbeing, including access to education, healthcare, housing facilities, employment and environmental issues. Obtained data was structured and linked with cartography basis. Official statistics data as well as sociological observations, discussion panels with government and non-governmental institutes in each of surveyed districts were used to develop maps.

In 2020 ICARDA together with the World Bank has prepared a report based on comprehensive study of options to mitigate adverse impact of SDS emerging on dried-up bed of Aral Sea and to evaluate benefits from the best intervention options for Uzbekistan. Aralkum desert with estimated area of 60 000 km2, emerged at the place of the sea, became one of the hottest spots of high salt content SDS in the world. This not only changes environment, worsening degradation and deforestation, but also causes deteriorating of sources of income and people's health. Continuous reduction of Aral Sea surface increases number of days with SDS, becoming prevailing factor comparing to other deserts in Central Asia. Analysis of wind parameters time series (speed, direction) revealed driving engines and frequency-based origin of erosion. For different soils of the dried-up Aral Sea bed general baseline of erosion stood at 10-15 m/s. During last two decades baseline wind speed was exceeded for 16 days a year in average, however, due to other favorable conditions, such as dry soils and wind direction, erosion lasted for only 9,4 days.

According to ICARDA report, salt and dust particles are permanently in the air, which may cause big number of deaths and life expectancy reductions due to cardiovascular and respiratory diseases. Though clear and reliable evidence of connection between dust impact and respiratory functions may be lacking, reports doubtlessly reflect severity of disaster in Aral Sea for public health, underlining knowledge shortfall and need for further focused research. Economic consequences of SDS, generated by Aralkum, obviously, have not been investigated sufficiently in publications. In previous reports for 2001, overall losses were estimated at 145 mln. USD annually for the whole region. Adverse impact of SDS on people's health has not been evaluated previously.

To asses SDS impact researchers first evaluated number and cost of local environmental services (soil organic carbon and biomass and etc.), which are lost due to non-implementation of the optimal measures. Further, researchers evaluated number and cost of certain environmental services lost outside site, such as: 1) number and estimated economic cost of statistical lives lost (SLL), which are determined by years of life adjusted as per disability-adjusted life years (DALYs); and 2) amounts and cost of production of various crops, losts due to SDS.

Regarding losses at the hottest spots, simulation model results showed that, in average 2,1 mln. t of soil organic carbon costing 207 mln.USD were lost due to SDS in recovered part of Aralkum within the territory of Uzbekistan. Moreover, around 2,0 and 2,7 mln. to of carbon (totaling 108 and 146 mln.USD), which could have been caught by the vegetation above and underground were lost.

Moreover, fourage and wood could have been collected, would optimal action at have been taken. So, lost cost of fourage and wood was estimated at 111 and 80 mln.USD, respectively. Considering 20 years vision period, omissions can induce material assets damages to the Republic of

Karakalpakstan ranging from 488 to 699 mln.USD in total locally, or 652 mln.USD in average, or 33 mln.USD annually, i.e. 1,54 % of Karakalpskstan's GDP.

Regarding losses outside hottest spots, considering, that Aralkum contribution to overall air pollution significantly decrease with the distance taken away from the spot, production losses of major crops growing in Aral Sea region are estimated from 5 to 14 mln.USD, or 10 mln. USD in average, i.e. 0,47% GDP of Karakalpakstan. General average number of SLL due to SDS annually is estimated from 13 to 29, or 21 in average, which is equal to 1,7 mln.USD (evaluated as 0,08% Karakalpakstan's GDP).

Simulation model studied intervention by various options of vegetation planting (shrubs or trees) and successful growing as a percentage of total area, showed that cost of eco-system, destruction of which can be prevented, and environmental services to create new eco-system are estimated from 146 mln. USD to 699 mln.USD.

The best option for actions will reduce SLL, which are being lost due to SDS emerging on dried-up Aral Sea bed by 12 (from 21 to 9 in average) costing 1,0 mln. USD, meaning 58 % reduction comparing to the current scenario with cost equivalent reaching 0,05% of Karakalpakstan's GDP. This prevents harvest losses in Karakalpakstan totaling in average 5,5 mln.USD, which is equal to 0,3% GDP of Karakalpakstan.

4.3. Participation of non-govermental organizations and local communities in national SDS management programs

Drought, SDS and other climate-induced changes and disasters generate large-scale social and economic, environmental impacts/challenges/eco-systems services worsening. Therefore, to implement national programs to combat drought and SDS a big number of concerned parties from targeted beneficiaries, local communities to government entities and non-governmental organizations, private sector as well as executive agency of the Global Environment Facility (GEF) and other international donors and partners.

Large-scale participation of non-governmental organizations and local communities (water users associations, rural residential communities, noo-governmental organizations, farmer and dekhan farms councils) in implementation of national programs on drought and SDS management, monitoring and public control will ensure feedback between government and public as well as boost transparency and accessibility of the program implementation results, particularly on local level.

Civil society contribution will be observed mainly in following:

- raising public awareness on goals, tasks, expected benefits from fulfilling liabilities in the framework of the Convention, particularly, national program on SDS;
- running the campaign to attract and raise public awareness on the actions taken by the Government to fulfill obligations in the framework of the Convention and implementation of the national SDS program;
- attracting intelligent and material resources, including resources of GEF's Small Grants Program;
- implementation of certain actions of the national SDS program and pilot projects to combat drought and SDS on local level and desertification in Aral Sea region;
- investigating public opinion in order modify/improve measures and actions of the national program on drought and SDS while the implementation;

- developing alternative national reports, reviews and papers on implementation of national programs on droughts and SDS.

Noteworthy, key tasks of national programs on droughts and SDS also include a need to integrate efforts on ensuring alternative income sources for population of exposed districts, mostly rural residents.

Main government entity involved in raising public awareness on environment protection issues, including preservation of biodiversity and eco-systems in exposed regions, is Information Service of the State Committee of the Republic of Uzbekistan on Ecology and Environmental Protection (Public Relations snd Media Department, Sector for Development of ICT). NGOs proactively work in the area of raising public awareness. Understanding importance of cooperation with NGOs, Ecology Committee developed «Recommendations on implementation and carrying out joint activities with non-governmental and non-profit organizations».

Public awareness raising activities accelerated since Fifth national report was produced in 2015. These activities are multifaceted both in terms of topics covered and groups targeted. In the framework of public awareness raising measures roundtables, seminars, trainings were organized, numerous publication were made, movies, videos, cartoons were produced, special mobile apps and multimedia educational programs were developed and etc.

Actions can be divided into following domains for actions:

- Preparing and distributing publications, including informational bulletins, brochures, booklets, visual aids, banners, advertisement, agitation and informational materials and etc.;
- Arranging media (newspapers, magazines, radio, TV, Internet) coverage of raising public awareness on the whole range of biodiversity values;
- Preparing special reports and focused papers, presentations at the meetings, round tables, conferences, including online conferences and webinars, publishing specialized, scientific and non-fiction materials;
- Preparing and publishing analytical reports for decision-makers;
- Hosting press-conferences, preparing documents for public deputies of the Senate and Oliy Majlis of the Republic of Uzbekistan;
- Developing and maintaining special websites and groups in social media networks, preparing publications for them;
- Arranging awareness-raising trips (media-tours), site visits, experience exchange trips, informational campaigns;
- Hosting international days related to World Day to Combat Desertification and Drought;
- Boosting activities in eco-tourism area;
- Creating information resources and visit-centers;
- Hosting exhibitions and contests on biodiversity;
- Hosting events on biodiversity monitoring with public involvement;
- Hosting trainings for different target groups;
- Taking part in environment protection actions, arranged on national, regional and global levels in the framework of conventions, funds, international organizations, international projects.

As a result of activities undertaken significant part of population gained basic knowledge and understanding of a value of a nature and importance of its preservation. However, transition from discrete, fragmented actions to systemic, comprehensive approach based on developed programs and actions plans with mandatory progress monitoring is required for maintaining the results achieved.

5. METHODS AND SCIENCE-BASED RECOMMENDATIONS ON ENGINEERING FACILITIES PROTECTION AND SDS IMPACT MITIGATION IN UZBEKISTAN

5.1. Methods to protect infrastructure, agricultural lands, engineering facilities from sand accumulation, SDS impact and aeolation of topsoil

Targeted actions aimed at forest resources recovery and sustainable use are required to expand forest area and forest resources sustainable management. This implies forest management and tailored intensity of its resources use enabling to preserve biodiversity. Sustainable forest resources use can enable forests self-recovery, further performing all their functions. Actions aimed at ensuring sustainable development of forest resources shall be supported in order to mitigate impact of human economic activity on existing forests. Introducing grazings control, prohibition of grazing at certain areas, facilitating forests natural recovery, fixing drifting sands, raising desert grazings productivity by planting protective forest vegetation and forage crops can serve as an alternative way for forest resources use. Special-purpose plantations to grow fuel plants will enable to significantly reduce existing pressure on trees and shrubs and, to certain extent, solve fuel demand issue. New technology and approaches facilitating reduction of trees and shrubs consumption as a fuel should also be introduced.

Major method used in Uzbekistan to combat drifting sands is installing mechanical cage-shaped protections from bullrush with further planting seeds and seedlings of saxaul and other desert plants within them.

5.2. Technology-based methods to use mechanical cage-shaped protection from bullrush and vegetative reclamation measures

So-called vertical mechanical protection strips from bullrush and tall-stalked grass with length ranging from 150 to 400 m2 per ha from barkhans' windward slope can be installed on sands to arrest drifting sands movement. Afforestation of sands is made based on initially installed mechanic protections by planting sprigs and seedlings of Calligonum and Salsola richteri (3-5 thousands of sprigs as well as planting 6-8 kg mixture of these species per 1 ha). Mechanical protection strips self-destroyed in 2-3 years while forest vegetation of Calligonum and Salsola richteri planted later on grew 1-1,5 m in the second year completely arresting sand movement underneath. After 3-5 years after forest vegetation planting barkhan sands surface became levelled and densified to certain extent, enabling to plant saxaul seeds (2-3 kg per ha) on interbarkhan hollows and smaller sand deposits. It will result in mixed vegetation plantings of Calligonum, Salsola richteri and Saxaul. Certain areas of plain terrains sands were planted with the seeds of black saxaul (Haloxylon ammodendron) (6-8 kg per ha).

«Border line» drifting sands, attacking Bukhara oasis, were arrested completely by 1934, «Bukhara green barrier» was created on north-western border of oasis by 1941 as a strip of 1-3 km wide sand-fixing planting stretching to around 120 km covering area of 25 thousand of ha.

Works on expanding green barrier continued after the Second World War. Large barkhan sands posing no threat to facilities were fixed with mechanical protection from tall-stalked grass with material consumption 80-120 m3/ha. Calligonum and Salsola richteri sprigs were planted with Kolesov's planting iron (1500 – 3000 units per ha), complementary seeding four kg of seed mixture of these plants. On medium and small sized drifting barkhan sands Calligonum and Salsola richteri sprigs were planted, followed by black saxaul seeds after 2-4 years.

Saxaul was planted with no preliminary preparation works on semi-stabilized stands and oversanded takyrs (6 kg per 1 ha). Between 1925 and 1960 over 150 thousand ha in oasis-adjacent sands of Bukhara province were planted with protection vegetation. Sand areas turned into year-round grazings for hundreds of thousands of sheeps and cattle. Impacted by vegetation, «Border line» sands levelled and densified to the extent enabling gardening, wineyards, cotton-growing. Eight years ago forestries in Bukhara province commenced works on planting second line of green barrier totaling 200 thousands ha alongside oasis borders. New green barrier is a continuation of the existing one. At present over 50 thousands ha of protective stands of black saxaul was already planted. Districts adjacent to green barrier saw sharp reduction of aeolation and agricultural crops sprout interference.

Similar experience on drifting sands fixing is used by the forestries in the Republic of Karakalpakstan, which fixed drifting sands and planting protective forest vegetation on 1,2 mln.ha on dried-up Aral Sea bed in 2019-2020 by means of aerial sowing, mechanical sowing and planting saxaul and other desert plants.

On plain terrains in desert areas protective forest planting is made in narrow strip with 8-10 m distance in between. This method of protective forest vegetation planting nowadays is used by almost all the forestries of desert zone.

Mechanical protection method with further sowing seeds and planting saxaul and other desert plants can be used in all areas across the country with drifting sands and ongoing deflation processes.

Recently, experiments are underway to use pelleted seeds of saxaul and other desert plants to fix drifting sands. Forest sites in drifting barkhan sands of Aral Sea region which machines can access can be planted by means of seeds pelleted with biologically stimulating yeasts using small aircrafts i.e. trikes. Experiment by the State Committee on Forestry made in Shofirkhan forestry in Bukhara province on 300 ha brought fruitful results. Sowing results Observation made in 2019 showed that over 50 % of trees took a root successfully reaching 1,5-2 m height and creating 6-7 m wide strip in every 30-40 m. In spring 2020 seeds with severed wings processed with no stimulators were planted on dried-up Aral Sea bed on 16,4 ha. Works in this domain should be continued.

5.3. Selection of technology and methods of protective forest planting depending on forest growth conditions and habitat conditions type

Prevention of further desertification processes development, degraded grazings recovery can be accomplished only by phytomelioration works, envisaging diversified selection of phytomeliorative substances for grazings located in various natural and regional complexes. Selection of phytomeliorative substances is made according to tolerance of different species to specific edaphic conditions of desert areas (grey-brown gypsum-bearing, salt marsh, desert sand soils of various intensity, takyr and other types and variations of desert soils). Works performed in south-eastern part of Kyzylkums showed that grazings productivity increases several times if phytomeliorated with artemisia, black saxaul and other vegetation species sowing.

Rational grazings use can target the changes of vegetation species composition and ensure economically beneficial mix of different plants. However, overgrazing results in excessive breaks in light desert soils developing barkhans, oppressing vegetation due to regular browsing and sprigs destruction. Annual grazing in the same time in spring-summer season results in vegetative cover degradation. Alongside with this, root phytocoenosis at first is replaced with a group of tall grasses and shrubs. Carex arenaria or Carex physodes, which fixes sands, falls out completely and baren sands site emerge. Imbalanced used of grazings, cattle concentration around crop planted and irrigated sites on poor grazings with homogenous fourage and underloaded inner desert sites where

fourage crops harvest is simply wasted unused are the main reasons for grazings deterioration. Long-term non-grazing on firmly fixed areas produces adverse impact on stand of grass, and in 4-5 years of non-grazing can reduce harvest by 20 %.

Grazings surrounding wells and boreholes are highly loaded. Soil in 2-8 km around them is completely baren. In suburbs of residential settlements plants are excessively cut for fuel. Remote sensing images clearly shows light stains indicating desertification around residential settlements, boreholes and wells. Non-regulated flowing saline water wells are the zones with intensive soils degradation. Excessive artemisia, Astragalus vilosissimus, Convolvulus hamadae and other herbs. Due to grazings degression last 15-20 years their root capacity is also decreasing.

Rodents are the major competitors to cattle for grazing plants, damaging up to 50 % of available fourage, eating rootstock, bulbs, seeds, and causing destruction of topsoil. Foxes, wild cats and other predators are the most efficient way to combat rodents. Comparing to 1950s grazings areas decreased by 6,5 mln. ha. Rational grazing use complying to the standards (6-6,2 ha per sheep) and accurate organized fourage grazing enhances economically beneficial ratio of vegetation species, its improvement and enriching.

Drifting sands are the centers of deflation. Vast areas across the country adjacent to desert zones are historically under the threat of drifting sands, dust storms and hot dry winds.

Major zones traditionally under sand deflation threat are Amudarya river delta, several regions of Khorezm province, adjacent to Kyzylkum desert; Alat, Karakul, Jandar, Kagan, Romitan, Karaul Bazaar districts of Bukhara provinces, adjacent to Sindukli sands; Mubarak, Bahoristan, Nishan, Usman Yusup districts of Kashkadarya province, which are also adjacent to Sundukli desert; Arnasay, Oktyabr, Pakhtakor, Mirzachul districts of Jizzakh province, adjacent to Kyzylkum. Pit-and-mound centers of drifting sands are located in Kyzylkum desert area and in Surkhandarya province. Sand drifting process itself poses serious threat with the regard to area desertification in Uzbekistan. It is not just sand accumulation in residential settlement area that burdens economic activity, but also continuous spendings on sand clearing from motor roads, hydromelioration system facilities, irrigated farm lands and etc, that produces adverse impact. Sand deflation as well as wind-induced erosion of irrigated soil cover cause reduced productivity, and as a result, smaller agricultural crops harvest amounts. Scientific researches as well as practical experience in Uzbekistan, Turkmenistan and of many other countries conducted comprehensive studies of the key indicators of drifting sands, enabling to undertake efficient measures to mitigate them.

Soil erosion. Environmental conditions in Uzbekistan themselves pose possible threat of emerging different types of soil erosion. Major reasons for erosion are irrational land use, non-compliance with the requirements on soil protection. In most cases it is related to planting crops slightly protecting from erosion on erosion-hazardous lands, irregular soil treatment on farming lands, uncontrolled cattle grazing, destruction of soil-protective plantings, and, in most cases, with violation of ecological requirements under lands irrigative and meliorative preparation. All types of erosion can be observed across the country, namely water-induced erosion (related to irrigation), wind-induced erosion (deflation) with harmful wind operation producing adverse impact not only on soils, but on plants, causing siccation, mechanic damages and etc. Mudflows' destructive activity is also peculiar to Uzbekistan.

Wind-induced erosion is the wide spread comparing to other types, covering 73 % of all farming, including 56 % of irrigated ones. Actively operating winds are specific to western and central part of Ferghana, south-eastern part of Mirzachul steppe, Karshi steppe, Bukhara oasis.

Atmospheric salt and dust transport. Halogeochemical cycle imbalance is the heaviest among the other abiotic factors in the region. While its full-fledged life period Aral Sea acted as natural salt recipient water body. Till 1960 Syrdarya and Amudarya were bringing over 25 mln. t of salt to Aral Sea annually. These salt settled in sea's water area and were involved in air transport processes with precipitations and aerosols, were partially filtered with ground drains, settled on

the sea bed, shallow lagoons, bays. Changed rivers' flow due to withdrawal of water for economic consumption (irrigation, watering, industrial needs) alongside with the other factors resulted in terminated distribution of this part of the salt stream across all the basin area, including zones of flow formation and consumption. Increase of mineralization degree of precipitations across the region, growth of mineralization level in the flow consumption zones, reduction of water-collecting basins area in the flow formation zones, increased land salinification level, hike in concentration of aerosols and salts in region's atmosphere, their transport across the region with air masses and further fall on the ground surface are the evidences to this process. So, data describing salt concentration changes in biosphere domains, namely soils, plants, atmospheric precipitations and dry drops, atmospheric aerosols are the crucial criteria of desertification.

Major problems related to studying atmospheric salt and dust transport in environment, its role in desertification of the territory of Uzbekistan are as follows:

- Lack of data collected on systemic basis on sources of dust, sand, salt transport to the atmosphere (temporary and site features);
- Lack of studies on mechanisms of sand storms and drifting dust emergence, processes of salt and dust transport under steady-state atmospheric conditions;
- Lack of state-of-the-art monitoring system over atmospheric salt and dust transport;
- Insufficiently studied impact of atmospheric salt and dust transport processes on environment, including biota, grazings, agricultural farms;
- People's health;
- Soils, surface water.

Contribution made by natural and anthropogenic sources in salt emissions was assessed based on the evidence from Bukhara province, southern part of Aral Sea and Ferghana valley in order to identify key components of the salt and dust transport process. Overall value of salts exposed to aeolian transport in Bukhara province area totals 167,136 thousand tons a year, including salt marsh export to atmosphere estimated by the experts to stand at 13,8 thousands of tones a year. Totally, average annual salt transport volume stood at 7683,83 t/km2. In general, these data provide certain information on aeolian salt, sand and dust transport sources assessment. Hence, a need to establish state-of-the-art system of monitoring over aeolian salt, sand and dust transport sources is quite obvious. This system have operate in fast-track coordinated mode enabling to forecast and observe emission sources, their development in area and period-wise. Gaps in estimated values of salt and dust transport made by various researchers demonstrated that further examination of these processes mechanism is required.

5.4. Introducing state-of-the-art methods and technology to mitigate and balance SDS centers

In Uzbekistan, as well as in the other Central Asian countries forests mainly act as protection and play a crucial role while combating SDS, preventing erosion and other natural disasters, and also in protection of irrigated agricultural farmings and grazings from degradation. Forests possess key renewable natural resources required for people's life. Alongside with wood, forests also provide such resources as habitats for fauna, water resources and recreation zones. Forest resources management in continuously changing world becomes more difficult setting new requirements to forest use.

The State Committee on Forestry developed a road map for 2019-2023. Based on this road map site work is accomplished across the country. For instance, in autumn-winter season of 2018–2019 seeds and seedlings of saxaul and other salt-tolerating plants were planted on 501 thousand of ha on the dried-up Aral Sea bed to fix drifting sands, in 2019-2020 the number reached 703 thousand of ha. In order to protect irrigated lands and infrastructure in districts adjacent to Kyzylkum desert in Bukhara province saxaul forest planting works commenced on over 200 thousand ha to create

green barrier around Bukhara. Moreover, pistachio plantations will be created on 10 thousand ha of Nurata piedmont in Navoi province. Alongside with forestry fund lands, forest planting to protect water reservoirs from salt penetration has also been included in the government program to improve melioration of irrigated agricultural lands. Within its framework trees were planted on 2 495 ha, in 2020 around 2 thousand ha were planted. Relevant Decree of the President of the Republic of Uzbekistan planting forest vegetation on 12 thousand ha in 2020–2024 on contractual basis to protect irrigated agricultural lands were included in the state program. Negotiations on establishing international discussion platform targeting major desertification, lands degradation and SDS issues are underway to ensure efficiently arranged combat against desertification and SDS.

6. GIS-BASED MAPPING OF THE MAJOR SDS CENTERS ACROSS UZBEKISTAN

Uzbekistan is the country, where natural sand desert occupy vast areas across the territory, mimor precipitations, arid and severe continental climate almost everywhere nationwide, significant gap between air temperatures in summer and winter season. Sun radiation intensity and duration of sunshine time, especially in arid periods, results in increased soil surface temperature and drought, early soil dry up on plain terrains area. Wind-induced erosion and transport of big amounts of silt and sand deposits result in desert area expansion, dust storms, especially in Aral Sea area and on southern provinces of the country.

Population of desert regions lives in extreme conditions. Due to dry-up of Aral Sea environmental conditions keep deteriorating in many regions. Critical ecological situation in Aral Sea region and Sariasiya district of Surkhandarya province as well in regions with SDS produce significant adverse impact on people's health .

Conventional ground surveillance methods are almost absolutely unsuitable to manage these areas situated all across the country, since they can cover only limited areas locally and the operational expenses are increasing annually. In such conditions remote monitoring (space sensing) and GIS analysis emerge as an alternative to conventional approach, being currently the most efficient and cheapest method of detection and monitoring of emergency situations occurrence in Uzbekistan .

GIS technology enables to collect, integrate, digitalize large scale data area-wise, comfortable to analize SDS processes nationwide. Based on visual content analysis GIS uses a set of different types of information ranged area-wise interpreted stemming from the position of concerned issue. In its simplest form of imposition GIS is a set of maps showing overlapping, coincided areas. For instance, we can compare land degradation map with soil texture and sample map to track possible locations SDS sources and their connection with soil texture or other variable sources. Topography, soil texture, its temperature and humidity, soil cover, wind speed and direction can be used to trace out SDS sources based on input maps and imposition analysis.

Seasonal dynamics of SDS sources is connected to seasonal vegetational changes, changes in water reservoirs dimensions and freezing under low temperature. These gaps result in significant change of SDS sources distribution area-wise. Drought as extreme weather conditions can result in SDS generation or in continuous activity of SDS dynamic sources. Human activity can produce both positive and negative impact on SDS sources activity. Methods of sustainable land resources management, such as afforestation and climate-adjusted agriculture, if applied, can reduce emissions of soil particles.

Efficient monitoring system shall include space segment, namely space apparatus on circular sunsynchronous orbits, equipped with active and passive sensing devices enabling various spatial

resolution in at the maximal range of electromagnetic spectrum. First of all, NOAA (resolution - 1100 m) and EOS AM TERRA (resolution - 250 m) public space systems are feasible to be used for continuous survey of the territory of Uzbekistan. «Landsat» (resolution - 30 m) and Sentinel-1 (resolution - 10 m) space ships provide the most affordable high resolution systems data.

Territory of Uzbekistan is highly covered with clouds which prevents from regular remote sensing in microwave range, thus, active sensing data, particularly from the ESA Sentinel-1 satellite have to used. This satellite is equipped with radar enables to obtain 10 m resolution good-quality pictures of Earth's surface regardless of cloud cover and time of the day .

Development of PPB initial maps requires involving big amount of human resources, particularly specialists to monitor and analize natural phenomena. Maps may contain controversial point. Research shall be continued expanding scope of resolved issues and engaging bigger number of specialists to develop detailed and reliable maps.

SDS source can be defined as baren topsoil surface exposed to wind-induced erosion, or any other surface emitting soil particles under favorable wind conditions. Conditions favoring soil particles emissions from such surfaces include low humidity of topsoil and surface wind speed exceeding certain minimal level which is closely related to topsoil granulometric texture and humidity. Soil surface is exposed to wind-induced erosion, if it contains finer soil particles, especially in disturbed soil structure, meaning that topsoil is of open texture and particles can be easily absorbed. If surface wind speed is high, sand particles (mostly, extra fine sand particles with diameter around 100 mkm) can be lifted and transported from the surface, though the distance they cross will be shorter comparing to smaller ones. SDS sources can be divided according to the changes in their activity into stable and dynamic SDS sources. As an examples to stable SDS sources can drawn those which are distributed across the desert areas and are permanently exposed to wind-induced erosion due to fine texture topsoil, continuous warm and dry climate, lack of vegetative cover or water reservoirs. Activity of dynamic SDS sources can change with the regard to the season, weather conditions and anthropogenic impacts.

7. Recommendations and National Action Plan

This document contains comprehensive analysis of SDS processes in Uzbekistan, since this phenomena has significant importance for people's lives, economy and agriculture. Recently, environmental situation in the country worsened due to strong winds and sand storms. Particularly, strong winds and sand storms were observed in Nukus city and several regions of the Republic of Karakalpakstan in June 14th, 2020 with roofs of multi-unit apartment buildings collapsed, fell on the ground destroying small shops and stands in the markets. We would like to remind that similar situation took place in May 26-27th, 2018. Strong wind lasted for a whole day lifting up to the air sand and salt particles from the dried-up Aral Sea bed and spreading salts to all the regions. Dust content in the air in Nukus while the storm exceeds the regular value 5,9 times.

In Surkhandarya province so-called «Afghan wind» annually blows from the south and comes to our country creating unfavorable weather conditions. Meanwhile, wind spreads a huge amount of sand across the streets and residential districts. While the sand storm people close doors and windows in the houses and seek for a shelter. Noticeably, residents of Aral Sea region as well as of Kashkadarya, Surkhandarya, Samarkand, Jizzakh and Syrdarya provinces also suffer from strong winds and SDS in material, economical, psychological and ecological way.

Afforestation enables to fix drifting sands, reduce wind speed in the upper part of surface and terminate sand and Dust storms. Researches show that sand migration in 3 years old haloxylon desert woodland reduces by 55%, in 5 years old one to 79,5 % and completely terminates in 7 years old forest. One mid-age haloxylon desert woodland hinders movement of 10 tones of sand fixing them with roots. Forest consisting of 1 ha of haloxylon desert woodland and Salsola absorbs

1135 kg of carbon dioxide and produces 835 kg of oxygen annually, improving air quality and limiting environment pollution.

People's health signigicantly depends on ecological conditions of environment. The better ecological situation is, the stronger is people's health. Haloxylon desert woodland and other shrubs lack in most of desert areas with sands coming into cities and rural settlements. Today sand heaps can easily be found everywhere in cities and regions. Number of these cases grows year by year.

In order to reduce adverse impact of strong winds and sandsstorms this document recommends as follows:

1. To develop and approve National Action Plan to prevent and mitigate SDS impacts in 2021-2023 (NAP);

2. To undertake analysis, elaboration and approval of laws and regulations governing SDS issues, improving economic stimulus mechanism to reduce land degradation and SDS occurence as well as enhancing cooperation on national, regional and international levels to combat SDS according to NAP.

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«Approved»

Deputy Prime Minister of the Republic of Uzbekistan

_____Sh. Ganiev

«_____» _____, 2021

Action Plan for enhancing potential on management and mitigation of adverse impact of sand storms and Dust storms in Uzbekistan for 2021-2024

№	Measures	Actions	Implementation terms	Source of funds	Responsible authority	Co-executives	Expected outcomes
1	2	3	4	5	6	7	8
1. Sistemic level							
1.1	Analysis of legislation and elaboration of new laws	To integrate SDS processes into the United Nations Office for Disaster Risk Reduction registry	2021	Bugdet	State Committee on Forestry	MFA	Engagement of each citizen of the country in creation and development of communities resilient to disasters
1.2		Analysis of laws and regulations governing sand and dust storms (SDS) related issues	2021	Budget in the framework of the projects	Uzhydromet, State Committee on Ecology	State Committee on Forestry, Ministry of Emergency Situations, Ministry of Healthcare, Sanitary and epidemiological stations	Alignment of SDS regulatory base, identification of key controversial documents burdening activities on SDS management

1.3		Improvement of the system of combatting desertification and environmental protection in Uzbekistan	2023	Budget in the framework of the projects	State Committee on Forestry	State Committee for Ecology, Ministry of Agriculture, Ministry of Water Resources	Measures will be developed to prevent SDS processes and reduce its negative impact Increased soil productivity, preservation of lands from anthropogenic and natural degradation
1.4	Mechanism of economic stimulus offered to the land degradation and SDS prevention measures to be improved	To improve mechanism of enhancing economic interest in efficient land use aiming at SDS impact reduction	2023	Budget in the framework of the projects	Ministry of Agriculture, Cadaster Agency	Ministry of Economy, Ministry of Water Resources, State Committee on ecology, State Committee on Forestry	Increased interest of land users and tenants' interest in efficient land use
2. Institutional coordination level							
2.1	Enhancing cooperation on SDS processes on the country level	To develop inter-agency coordination programs on sustainable land management	2022	Budget	State Committee on Forestry, Ministry of Agriculture	Uzhydromet, State Committee on Ecology, Academy of Science, Committee for sericulture and karakul farming	Increased efficiency of inter-agency cooperation on SDS related processes management
2.2		To establish national expert network on land and water resources related issues concerning SDS	2022	Budget	State Committee on Forestry	Ministry of Agriculture, Ministry of Water Resources, Committee for sericulture and	Increased efficiency of cooperation in SDS area between all concerned parties

						karakul farming, State Committee on Ecology	
2.3		To establish a Center for lands monitoring related to SDS based on geographical information system data	2022	Budget in the framework of the projects	State Committee on Forestry, Uzhydromet	Ministry of Agriculture, State Committee on Ecology, Academy of Science, Council of Ministers of the Republic of Karakalpakstan, Province Mayor's offices	State of the lands shall be evaluated and forecasted to the extent of impact SDS processes produce on them. Environment shall be created for efficient land use, recovering their productivity in terms of drought
2.4		To file and inventory on sources of SDS formation across the country	2022	Budget in the framework of the projects	Uzhydromet, State Committee on Forestry,	Ministry of Agriculture, State Committee on Ecology, Council of Ministers of the Republic of Karakalpakstan, Province Mayor's offices	Registry of effective, exhausted and newly identified drought area shall be made. Further SDS formation shall be forecasted with the opportunity to tailor measures to combat SDS
2.5	Strengthening regional and international cooperation on SDS related processes	To strengthen efforts and actions coordination between Central Asian countries on SDS adverse impact management on regional level	2023	Budget in the framework of the projects	State Committee on Forestry	MFA	Institutional potential to be created by establishing regional personnel training center, holding international conferences, raising public awareness and developing

							recommendations for the governments of the Central Asian countries in the framework of their efforts to combat SDS
2.6		To develop and implement innovation projects and solutions to combat SDS in Central Asia	Continuously	IFIs and donors	State Committee on Forestry	MFA, Ministry of Agriculture, other concerned ministries and entities	Mechanism of exchange in SDS combat related knowledge, technology and experience put in place on regional level and attracting IFI funds to combat SDS
3.	**In the area of reducing the level of desertification and land degradation, recovering land quality and productivity:**						
3.1	Improvement of the mechanism for combatting desertification and SDS	To undertake measures to combat desertification set forth in the "Convention for forestry development in the Republic of Uzbekistan by 2030" approved by the Resolution of the President of the Republic of Uzbekistan No. PP-4850 dated October 6th, 2020	2021-2023	State special and local budgets, IFI funds	State Committee on Forestry	Ministry of Agriculture, Ministry of Finance, Council of Ministers of the Republic of Karakalpakstan, Province Mayor's offices	Further land degradation and desertification shall be prevented across the country.
3.2		To establish commissions on local	2021-2023		Council of Ministers of the	Concerned ministries and entities	SDS prone areas will be identified, and measures to

		areas to take inventory of the sources of SDS formation and develop a proposal for combating them			Republic of Karakalpakstan, Province Mayor's offices		combat them will be proposed
3.3		To establish a commission to develop mechanisms for an early warning system for the expected risks of SDS in Uzbekistan	2021-2022		Uzhydromet, State Committee on Forestry, Council of Ministers of the Republic of Karakalpakstan, Province Mayor's offices	Concerned ministries and entities	The early identification of threats and warning government agencies, economic sectors and population on possible SDS

APPENDICES

Appendix 1 - Total land area of the Republic of Uzbekistan

as of January, 2020 (thousand ha)

№	Region	Total land area		Cultivated area			Perennial shaw		Wildlands		Hayfields and grazings		Agricultural lands		Home grounds and gardening plots		Reclaimative lands	Forests		Shrubs	Other lands
		Total	Irrigated	Total	Irrigated	Non-irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Non-irrigated	Total	Irrigated	Non-irrigated	
A	**Б**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	Republic of Karakalpakstan	16656.1	514.6	418.5	418.5		8	8	11.2	11.2	5257.4	36.8	5695.1	474.3	52.4	39.4	24.6	1072.8	0.9	107.1	9704.1
2	Andijan	430.3	274.2	200.6	200.6		31.1	31.1	2.6	0.5	21.1	0.9	255.4	233.1	50.6	37.2	0.9	3.9	3.9		119.5
3	Bukhara	4183.1	274.9	200.1	200.1		20.8	20.8	7	7	2558.1		2786	227.9	58.4	45.3	4	334.5	1.7	45.4	954.8
4	Jizzakh	2117.9	303.9	489.3	259.9	229.4	22.3	17.4	11.3	1.7	739.1		1262	279	34.6	20.4	5.1	163.7	4.5	0.1	652.4
5	Kashkadarya	2856.8	514.1	675.7	417.3	258.4	39	36.7	21.9	4.6	1406.8	0.1	2143.4	458.7	80.4	49.4	18.7	164.3	6		450
6	Navoi	10948.1	126.4	122.9	92	30.9	10.3	9.6	6.8	6.7	8762.3		8902.3	108.3	26.3	16.6	2.8	1270.8	1.5		745.9
7	Namangan	718.1	290	188.2	188.2		46.4	46.4	2.5	2.5	150.8		387.9	237.1	58.8	48.4	0.8	23.4	4.5		247.2
8	Samarkand	1677.3	379.2	429	246.9	182.1	68.1	63.4	5.2		797.1		1299.4	310.3	87.2	62.9	3.6	13	6		274.1
9	Surkhandarya	2009.9	325.1	278.1	238.8	39.5	34.2	32.8	0.3		826.5		1139.1	271.4	63.2	50.4	1.3	233.4	3.3	0.1	572.8
10	Syrdarya	427.6	286.3	249.2	249.2		7.4	7.4	10.3	10.3	20.5		287.4	266	19.3	15.3	4	4.1	4.1		112.8
11	Tashkent	1524.9	400.3	329	295.7	33.3	53.6	44.3	0.8	0.4	445.6	1.4	829	341.8	68.1	56.1	0.2	81.7	2.4	2.3	543.6
12	Ferghana	700.5	368.5	247.6	247.6		49.4	49.4			23.4	3.9	320.4	300.9	72.8	53.7	1.9	14.6	13.9		290.8
13	Khorezm	608.2	267.7	205.3	205.3		13.2	13.2	3.8	3.8	109.3		331.6	222.3	54	45.2	1	53.7	0.2		167.9
14	Tashkent city	33.6	3.8										0	0	7.1	3.8					26.5
	Total	**44892.4**	**4329**	**4033.5**	**3269.9**	**773.6**	**403.8**	**380.5**	**83.7**	**48.7**	**21118**	**42.9**	**25639**	**3732**	**733.2**	**544.1**	**68.9**	**3433.9**	**52.9**	**155**	**14862.4**

Appendix 2 - General-purpose use land of agricultural enterprises in the Republic of Uzbekistan

as of January, 2020 (thousand ha)

№	Regions	Total land area		Cultivated area		Perennial shaw		Wildlands		Hayfields and grazings		Agricultural lands		Home grounds and gardening plots		Reclaimative lands	Forests		Shrubs	Other lan
		Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigate led	Total	Irrigated	Total	Irrigated	Irrigated	Total	Irrigated		
А	Б	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Republic of Karakalpakstan	3260.3	500.4	414.8	414.8	7.8	7.8	9.4	9.4	1768	34.3	2200	466.3	40.4	33.5	23.5	49.6	0.6	44.2	902.6
2	Andijan	363.7	265.3	199.3	199.3	30.4	30.4	2.3	0.5	17.7	0.9	249.7	231.1	43.4	32.3	0.9	1.9	1.9		67.8
3	Bukhara	3441.7	271.6	199.5	199.5	20.5	20.5	6.6	6.6	2355.4		2582	226.6	56.9	44.4	4	7.9	0.8	5.1	785.8
4	Jizzakh	1400.7	299.3	486.3	259.2	20.6	16.7	11.2	1.7	621		1139.1	277.6	31.1	18.2	5.1	9.4	3.5	0.1	215.9
5	Kashkadarya	2322.7	506.5	671.1	415.7	38.2	36.1	20.6	4.4	1214.2	0.1	1944.1	456.3	73.8	46	18.6	11.2	4.2		275
6	Navoi	4501.8	123.7	119.6	91.5	9.8	9.1	6.7	6.5	3852.6		3988.7	107.1	24.3	15.7	2	0.9	0.9		485.9
7	Namangan	490	274.4	185.8	185.8	44.5	44.5	2.4	2.4	46.9		279.6	232.7	47.4	39.4	0.8	5	2.3		157.2
8	Samarkand	1476.4	368.8	425.6	246.1	63.7	62.4	5.2		707.1		1201.6	308.5	79.5	57.9	3.6	4.5	2.4		187.2
9	Surkhandarya	1357.1	318.3	276.4	237.5	33.2	32.1	0.3		690.4		1000.3	269.6	58.4	47.2	1.3	29.1	1.5		268
10	Syrdarya	370.2	278.8	246	246	7.4	7.4	9.6	9.6	18.6		281.6	263	17.3	14	3.2	1.9	1.8		66.2
11	Tashkent	778.2	385.5	324.5	293.8	51.8	42.8	0.7	0.4	207.5	1.4	584.5	338.4	55.7	45.8	0.2	7.8	1.3	1	129
12	Ferghana	561.1	354.3	246.8	246.8	48	48			19	3.5	313.8	298.3	65	49	1.8	6.9	7		173.5
13	Khorezm	437.7	263	202.8	202.8	12.8	12.8	3.7	3.7	41.3		260.6	219.3	51.4	43.5	1	14.3	0.2		110.4
14	Tashkent city																			
	Total	20761.6	4216.1	3998.5	3238.8	388.7	370.6	78.7	45.2	11559.7	40.2	16025.6	3694.8	644.6	486.9	66	150.4	28.4	50.4	3824.6

Appendix 3 – Mortality and diseases rate in the Republic of Karakalpakstan in 2019

	Mortality						Morbidity				
Region	**CHD**	**Insult**	**Lung Cancer**	**COPT**	**LRTD**	**Diabetes II type**	**Chronic Bronchitis**	**Hospi Taliza Tion**	**Work days lost**	**Limited Activity Days**	**Acute Low Respiratory Tract infections (children)**
Nukus	17	155	168	1	196	12	3196	394	10240	26311	28
Beruni	213	90	85	91	0	5	5069	0	397	397	88
Turtkul	120	38	1	18	7	16	225	16	493	493	6
Ellikkala	76	25	82	10	3	20	81	10	250	250	6
Amudarya	244	122	4	7	4	32	501	233	2796	0	1439
Takhiatash	46	37	2	5	7	7	685	495	15	106	36
Khojeyli	66	78	4	39	1	12	272	473	766	0	47
Kanlikul	19	20	0	37	0	3	47	2	382	0	7
Kungirot	63	21	2	17	2	15	237	237	2002	2002	155
Moynak	69	5	18	3	10	3	24	5	152	152	759
Shamanay	19	30	0	32	0	3	47	3	330	330	12
Keteyli	194	0	53	0	0	2	70	11	1151	14	3
Nukus District	72	6	1	1	0	0	61	61	457	457	550
Chimbay	151	65	0	29	0	2	104	58	129	58	19
Karauzyak	47	23	3	0	1	2	67	67	530	530	1060
Takhta-Kupir	63	0	0	0	0	1	22	6	149	0	0
Total	**1476**	**715**	**423**	**290**	**231**	**135**	**10708**	**2071**	**20239**	**31100**	**4215**

Note: CHD - coronary heart disease; COPT - Chronic Obstructive Pulmonary Disease; LRTD - Low Respiratory Tract Disease.

Appendix 4 - Land disbursement by soil type in Uzbekistan (Talipov, 1992)

Soil type	Area, mln. ha	Share (%) in total available area	Level above sea, m
Flatlands zone			
Gray brown cinnamonic soil	11.5	25	150-250
Sandstones	1.37	3	120-150
Takyr soil	1.78	4	120-180
Meadow takyr soil	0.47	1	120-150
Meadow and swampy meadow soils	1.85	4	80-100
Salt marshes	1.27	3	80-100
Sands	12.1	28	120-150
Piedmonts and mountains zone			
Light gray soils	2.59	6	250-500
Regular nullzem	3.05	7	500-700
Dark sierozem	1.06	2	750-1200
Cinnamon brown medium altitude soil	1.66	4	1200-2800
Light brown high altitude soil	0.54	1	2800-3500
Meadow sierozemic soil	0.78	2	250-500
Meadow and swampy meadow soils	0.75	2	250-500
Stony soil	3	6	-
Water surface area	1.12	2	-
Total:	44.89	100	

Appendix 5 - Air temperature difference between decades

1951-1960 and 1961-1970 (1), 1951-1960 and 1971-1980 (2), 1951-1960 and 1981-1990 (3), 1951-1960 and 1991-2000 [8]

Station	January				April				June				October			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Barsakelmes	-0,5	1,8	-1,4	-	-0,5	-1,5	-2,0	-	-0,5	-1,6	-3,0	-	0,5	1,3	1,5	-
Aral Sea	-0,5	1,2	-3,3	-2,0	-0,7	-1,5	-1,7	-3,0	-0,3	-1,6	-2,8	-1,7	0,2	0,8	0,2	-1,2
Uyali	-0,5	2,2	-1,9	-	-0,8	-1,7	-2,8	-	-1,1	-1,3	-3,4	-	0,8	1,8	2,0	-
Muynak	-0,1	2,9	-1,1	-0,2	-0,8	-1,9	-3,0	-4,7	-0,8	-1,4	-2,4	-2,8	0,7	1,2	1,8	0,1
Tigrovy	-0,3	2,0	-	-0,8	-1,7	-	-	-0,8	-1,5	-	-	0,6	1,4	-	-	
Portalau	0,4	3,3	-1,4	-	-0,5	-1,4	-1,9	-	-1,6	-1,1	-2,6	-	0,4	0,5	0,9	-
Chimbay	0,4	2,4	-2,0	-0,4	0,4	-1,3	-1,5	-2,9	-0,8	-1,5	-2,3	-2,1	0,2	-0,3	-0,2	-1,6
Khiva	0,1	2,4	-1,2	-0,8	0,3	-0,7	-0,6	-0,6	0,4	-0,4	-1,2	-1,5	0,8	0,0	0,2	-1,2
Jaslyk	0,4	3,2	-2,5	-1,1	0,0	-0,1	-1,2	-2,8	-0,7	-1,0	-2,3	-1,7	0,2	-0,3	-0,3	-1,5
Karakalpakiya	0,4	3,0	-2,2	-1,4	-0,1	-0,6	-1,6	-3,5	-0,4	-1,8	-2,2	-1,6	0,3	-0,2	-0,5	-2,1
Akbaytal	0,7	2,4	-1,4	-0,2	-0,2	-0,9	-0,6	-0,6	-0,2	-1,1	-1,5	-0,9	0,4	-0,1	0,3	-1,5
Tamdy	0,7	2,3	-1,6	0,1	-0,4	-1,3	-0,8	-0,8	-0,7	-1,4	-1,6	-1,2	-0,2	-0,8	-0,2	-1,6

Appendix 6 - Disbursement of lands in the Republic of Uzbekistan

as of January, 2020 (thousand ha)

№	Land category	Total area		Irrigated lands	
		Total	%	Total	%
1	Agricultural lands	20 761.6	46.25	4 210.1	9.38
2	Settlement lands	223.4	0.50	52.7	0.12
3	Lands used industry, transportation, communication, defense and other purposes	867.4	1.93	12.7	0.03
4	Lands used for nature protection, recreational and health-improving purposes	731.7	1.63	0.6	0.001
5	Lands used for istorical and cultural purposes	14.6	0.03		
6	Forest area	12 020.7	26.78	45.9	0.10
7	Water fund land	835.3	1.86	4.7	0.01
8	Reserve area	9 437.7	21.02	2.3	0.005
	Land, total	**44 892.4**	**100**	**4 329**	**9.64**