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INTERACTIVE GEOINFORMATION MAP OF DEGRADED PASTURES OF KAZAKHSTAN WITH DIFFERENT DEGREES OF DEGRADATION AND MEASURES FOR THEIR MANAGEMENT

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ABSTRACT

This paper presents an assessment of pasture areas of Kazakhstan with different degrees of degradation of desert, foothill semi-desert (vertical zoning), semi-desert (latitudinal zoning), dry-steppe, steppe and forest-steppe zones using GIS technology based on field survey data with indicators of physical (soil) and biological (botanical) indicators and medium and low resolution satellite data. The aim of this work is to develop an interactive geo-information map of pasture degradation in Kazakhstan. To determine pasture degradation, the remote sensing (RS) method was used with all available mapping material and satellite data from Landsat 8, Sentinel 2, Modis TERRA, which resulted in analysis of vegetation indices NDVI, SAVI, BareSoilIndex, SalinityIndex, Top-SoilGrainSizeIndex for 33 monitoring areas in 12 oblasts in the context of degradation contours. A database for all soil-geographical zones was compiled and an interactive geo-information map of the degree of pasture degradation for the studied soil-geographical zones of Kazakhstan at a scale of 1:750 000 was developed, which includes soil, botanical characteristics and measures for their management and improvement.

Keywords: *Monitoring, GIS Technology, Remote Sensing of the Earth (RSE), Physical Indicator, Biological Indicator*.

1. INTRODUCTION

Pastures make up about 70% of the entire territory of the republic and are the main potential for the effective development of animal husbandry.

Rangeland degradation is caused by several factors such as overgrazing, wind erosion, water erosion, dryland salinity, chemical soil contamination and so on. The discussion that follows mainly focuses on the problem of pasture overgrazing, according to Mexican scientists [1]. Grazing overgrazing is related to the practice of allowing far more animals (e.g. goats grazing on the tamaulipan rut in north-eastern Mexico) to graze in a certain place than it can actually sustain. As a result, overgrazing by different types of livestock represents perhaps the most significant anthropogenic activity that degrades natural grasslands and leads to desertification in terms of plant density, plant chemical content, community structure and soil erosion.

Kazakhstan's pasture resources are very extensive, but they are far from being used rationally [2]. Recently, due to continuous and irregular grazing of animals on the same areas of pastures from early spring to late autumn, and in a number of areas in winter, in a relatively short time, it led to the loss of valuable readily eaten plant species from the grass stand, to thinning vegetation cover, and later to failure and the appearance of wind soil erosion. At the same time, naturally, first of all, the condition of grass stands in pastures located around rural settlements and water sources worsened, while the radius of degraded areas reaches 3-5 kilometers. In recent years, this negative process tends spread further, since according to static data, the area of desertified and degraded lands is more than 15% of the country's territory, out of 180 million hectares of pastures of extreme degradation (failure) they reached 27.1 million hectares [3]. In addition, the analysis of the state of development of the agro-industrial complex of Kazakhstan in recent years shows that the low productivity of forage lands, especially in unfavorable years in terms of moisture, does not allow sufficient supply of adequate feed for the

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existing livestock of farm animals. In this regard, there is a need, focused on the production of livestock products, to develop measures and outline ways to increase the productivity of forage lands by improving and rational use of pasture lands. One of the ways to prevent further degradation of pastures is the introduction of scientific and technological progress in pasture farming, namely the use of a geographic information system.

Pickup et al. [4] demonstrated the potential of using remote sensing technology to identify land degradation trends in non-equilibrium natural grasslands in arid Australia. They show how trends in natural grassland condition can be identified from changes in vegetation growth patterns over time along gradients of varying grazing intensity. Grazing intensity was measured indirectly using distance from water. Vegetation growth was derived from remotely derived vegetation index values before and after heavy rainfall. The growth value was adjusted to the initial vegetation cover to obtain a standard measure of vegetation response.

The vegetation response coefficient was obtained by comparing areas less than 4 km from water with reference areas even further away. Systematic changes in this coefficient over time show a definite trend. The values of the coefficient in the test areas indicate decreasing, improving and no change, coinciding with the current management history. This method can be applied where the entire area is affected by grazing and where there are no relatively old reference points.

Consequently, it can be useful in semi-arid natural grassland where grazing is less than in the arid part. It can also be applied in natural pastures. There is a possibility to apply this method also to traditional grazing systems. This method is cheaper and more efficient than other methods, increasing the potential for gradient-based grazing monitoring schemes in arid and semi-arid lands.Landsat data serve as the main source of high-resolution images for detailed pasture surveys. The high-resolution images show many features, such as different pasture conditions, barren areas resulting from overgrazing near watering holes, and accumulation of cattle tracks emitted by holes and so on. Image processing techniques can be applied to highlight these features.

The spatial resolution of Landsat TM is insufficient to characterize the plant community in arid and semi-arid zones. This has led to unmixed spectra in order to extract more detailed information on withered vegetation, soil, and photosynthetically active vegetation. The algorithm is designed to achieve sub-pixel-level accuracy.

Spectrum splitting means identifying spectral finite elements (pure spectral classes, e.g. vegetation and soil). In most cases, a linear blending technique is used that estimates the proportion of each ground pixel region belonging to different cover types.

The spectral reflectance for the final elements can be obtained from spectral libraries based on measurements under controlled laboratory or field conditions, or by determining pure pixels that contain one spectral class. Within a single pixel, the contribution from a single end element to the overall luminance or reflectance is proportional to the local coverage of that end element.

A simple linear stratification or unmixing algorithm is used, and, the total number of finite elements does not exceed the number of spectral bands used for stratification (unmixing), which allows a solution (more known parameters than unknown parameters). The unmixing result is the fraction of each finite element in each individual pixel. Unmixing spectral analysis is probably the most reliable alternative to vegetation indices for studying vegetation in arid areas

It should be noted that there is practically no monitoring system for the condition and efficient use of pastures in the republic. Development of such a system will allow improving the situation with the fodder base available to the farmer and will give an impetus to the growth of livestock and livestock productivity.

Based on the results of studies on remote sensing of land, field work and the use of indicators of physical and biological indicators of degradation, develop an interactive geoinformation map and assessments on the degree of degradation of pastures and their management in various regions of Kazakhstan.

Based on the research conducted, the symbiosis of science and information technology is seen as the most promising. The use of the developed geoinformation map allows us to analyze the degree of degradation of pastures and to develop measures for their improvement.

2. MATERIALS AND METHODS

The research was carried out between 2018 and 2020 on the rangeland areas of Kazakhstan, to determine the extent of their degradation and to develop a geo-information map. This electronic map should show soil and vegetation (botanical) characteristics, degrees of degradation and measures for their improvement and restoration. The methodology, methods and forms of scientific

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research that will be used in this program correspond to the main trends of advanced scientific research. The methodology of pasture research is based on systemic, natural-historical, landscape-ecological and natural-aesthetic approaches, which make it possible to view pasture resources as open dynamic systems that ensure sustainable functioning and ecological well-being of human life, economic and natural components of natural-agricultural systems. The program is interdisciplinary. In the course of its implementation, the methods and methodology of agricultural science and the science of space research will be used.

Much attention is paid to the method of decrypting remote sensing data, which will quickly solve the tasks set for the accurate identification of characteristic objects with the manifestation of degradation processes in them, establishing and clarifying boundaries and their state. In the field of grassland resources assessment, the application of RS digital technologies and field research, it is decided to really assess the state and opportunities for the restoration of pastures, which is necessary to address the issue of increasing livestock productivity, sustainable land use and food security of the republic.

2.1 Field Research

At each base field line (selected by satellite images), studies will be conducted on indicators of physical (soil) and biological (plant) indicators. Data acquisition is carried out in the base areas on 4 levels of pasture degradation: 1- weak, 2-medium, 3-strong and 4th-failure.

In order to determine the biological performance of the plants, it is necessary to determine: name of the plant community (background); species composition (for 1m ^{2}) and botanical composition of plants (%); poisonous and inadequate plant species (% in yield); projective cover of soil by plants (%); yield of pastures (centners / ha with natural moisture); quality of feed (feed units); the presence of grazing.

The research work related to the biological indicator is carried out according to the following approved methodology guidelines:

- Geo-ecological monitoring indicators of the pastures under study (grass species composition, degree of pasture degradation, plant deposition) were studied [5].

- The methodological basis for mapping to form a geo-information map of the degraded pastures under study in Kazakhstan was studied [6].

- According to the instructions, a botanical-feeding survey of degraded pastures was carried out on the study plots (1 m^2), the botanical composition of the plants was determined and their fodder values calculated [7].

- According to the methodology of the experiments, the degradation index of the projective cover of pasture grass mixtures was investigated in the pastures to develop planned surface and root improvement measures [8].

- The baseline, intermediate and final state of the degraded pastures (quantitative and species composition) at the start of the study were studied and planned improvement measures were developed. The quantitative and species composition of the grass mixture and the degree of plant deposition were determined on a dedicated plot (1 m^2) [9].

- The number of plants per 1 m^2 was determined in the allocated plot, based on which the percentage of projective cover of pastures was determined. According to this methodology, the status indicators of the species composition of the grass mixture of the degraded pastures under study at the beginning of the study were studied [10].

The research on the physical indicator is based on traditional methods. At the stage of conducting field research, morphological methods shall be carried out. Laboratory and analytical studies of soils shall be performed according to generally accepted methods. The compilation of a soil map shall be made by mapping using remote sensing materials using GIS technologies. The following indicators shall be used:

-determination of the humus horizon thickness,

- humus content in humus horizons,

- determination of the amount and composition of exchange cations,

- determination of the particle size distribution of the soil along the soil horizons,

- determination of soil pH,

- definition of mobile nutrients (N, P, K) of the soil [11].

Definition of the degradation of pastures by means of data of the remote sensing of the earth (RSE) was carried out with attraction of all available cartographic materials across the territory of a research and replenishment him the thematic cards received as a result of processing of satellite data of Landsat 8, Sentinel 2, Modis TERRA [12-14].

The main satellite indices used for calculation are:

- NDVI (Normalized Difference Vegetation Index), this index shows the degree of soil vegetation cover (dense, thinned, moderate, downy, waterlogged, reedy).

- SAVI (Vegetation Index adjusted for soil), this index indicates the degree of salinity and salinity of the soil (slightly, moderately, strongly);

- BareSoilIndex (Open Soil Index), this index shows the land surface (water, marshes, shoals);

- SalinityIndex (Salinity Index), this index indicates the degree of soil salinity (solonchaks, salts, solodiles);

- Top-SoilGrainSizeIndex (Index of sand fractions), this index shows the granulometric composition of the soil (clay, sand, taky).

3. RESULTS

In 2018 we developed and used in field works the indicators of physical biological indicators to determine the degrees of degradation of pastures of foothill-semi-desert and desert zones of Kazakhstan. Route studies conducted on grey-brown soils, grey soils and sandy desert soils of the studied region allowed obtaining 240 soil indicators and 280 biological indicator indicators. These indicators and stock material were used to develop digital mapping material on the degrees of pasture land degradation in the foothill semi-desert (vertical zonality) and desert (latitudinal zonality) natural zones. Based on the results of the research a digital map of pastures in M 1:1 000 000 by strong, medium and weak degradation of foothill semi-desert and desert zones of Kazakhstan was formed [15-17].

According to the results of studies in 2019 a database pastures of semi-desert and arid-steppe zones of Kazakhstan was compiled, including the following indicators: by physical indicator were determined: type and sub-type of soil, profile morphology, thickness of humus layer, granulometric composition, humus content, water-soluble salts, absorbed sodium in 0-30 cm layer of soil, by biological indicator were determined: projective cover, species botanical composition and productivity of pasture forage. NDVI vegetation index was analysed for each polygon in terms of degradation contours. A map of pasture degradation degree of semidesert and arid-steppe zones of Kazakhstan M 1:1 000 000 was constructed [18,19].

Data on the results of studies conducted in 2020 in the steppe and forest-steppe zones of Kazakhstan allowed to identify degraded pasture lands with different levels of degradation and localize further spread of degradation through the use of technology to restore and improve the degraded areas. A map of the degree of degradation of pastures in the steppe and forest-steppe zones of Kazakhstan M 1:1 000 000 has been developed [20,21].

Based on the conducted terrestrial and space-based studies for 2018-2020 [22,23], we developed an interactive geoinformation map of degraded pastures with various degrees of degradation of Kazakhstan on a scale of 1:750 000, in which the studied conditions of soil and biological indicators on degraded pasture lands in desert, foothill semi-desert (vertical), semi-desert (latitudinal), dry-steppe, steppe and forest-steppe zones were integrated (Figure 1), along the route: Lepsy, Koksu, Koskudyk and Aidarly in the Almaty region, Zhambyl, Moyinkum and Akkol in the Zhambyl region, the Kyzylkum sands in the Kyzylorda and Turkestan regions, Gulshat, Akshatau, Aksu-Ayuly and Atasu in the Karaganda region and Zhalgyztau in the Zhalgyztau region, Tasty-Taldy and Prirechny in Akmola region, Kalkaman and Akku (Lebyazhye) in Pavlodar region, Shar and Zhangyztobe in East Kazakhstan region, Tasmola and Almaznoye in the West Kazakhstan region, Martuk and Khlebodarovka in the Aktobe region, Adai and Pereleski in the Kostanay region, Andreevka in the North Kazakhstan region, Atameken and Bozaigyr in the Akmola region, Yubileiny and Peschanoye in Pavlodar region in the Semenovka and Vostochno Kazakhstan oblast, a total of 33 monitoring sites in 12 oblasts with the determination of the degree of pasture degradation at each of the monitoring sites. ArcGIS is a system for working with online maps and related geographic information.

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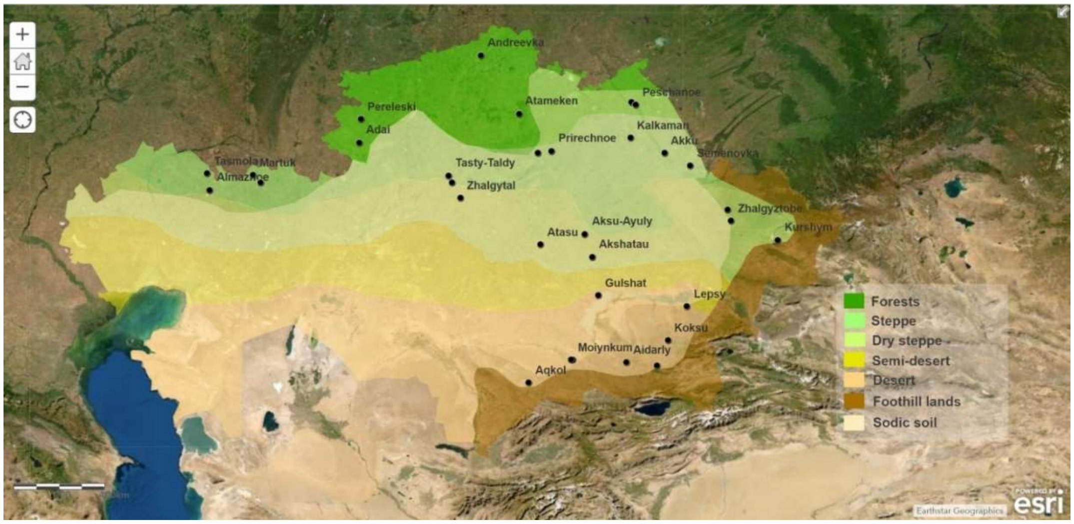

Figure 1: Interactive Geo-Information Map of Degraded Pastures with Different Degrees of Degradation for Different Soil and Geographical Zones of Kazakhstan

With ArcGIS, it's possible to create an interactive map that displays, integrates, and synthesizes significant layers of geographic and descriptive information from a variety of sources. ArcGIS maps are interactive windows that can be used to visualize, explore, and analyze this information. To visit portal, one needs to use the following link: http://arcg.is/Cau5e, the map with the toolbox is available at the following address https://arcg.is/0mqHPC, to go to the soil map with the toolbox, copy this address: https://arcg.is/vuuvT.

The maps interactively show zones of degraded pasture surfaces, soil, botanical data and measures for their management, the location of deserts, rivers, lakes, solonetzs and other objects with built-in attributive information. Changes in spectral images of vegetation in desert and semi-desert zones are shown, depending on the degree of degradation, which is quite vivid. In these studies, heavily used areas approach the nature of the spectral reflection to the graphs of bare soil. The spectrum is dominated by open soil and vegetation remains. Medium and low degradation in the autumn period also has the character of a bare area.

It is rather difficult to assess the state of vegetation from autumn images. Taking into account the reflectivity in the NIR range, a good state of the plant community is noted on the contours with low degradation. However, most plant communities have no changes in the red range of the spectrum. This means that most of the plants have finished their growing season.

Thus, on the basis of spectral characteristics, according to degradation stage of soil and plant communities, four stages of degradation were identified: failure, strong degree of degradation, medium and weak.

In the steppe, dry-steppe and forest-steppe zones, on the basis of spectral characteristics, according to the degradation stage of soil-plant communities, three degrees of degradation have been identified: a strong, medium and weak.

With the homogeneity of the soil cover, the influence of various degrees of pasture degradation on the thickness of the humus horizon (decrease from 75 to 65 cm), the content of humus in it (decrease from 0.9 to 0.6%) is quite clearly manifested, which had a noticeable reducing effect on the other indicators of elements soil fertility, except for the content of water-soluble salts. On the plots, there is a low projective soil cover with vegetation, this is especially clearly seen on the contour, where a very strong grazing was carried out (10% in the failure contour).

With a decrease of load on pastures, the projective cover of the soil with grass stand also increases on the contour, where a weak degree of grazing is noted, it reaches 70%. This interactive map, collected in a single portal, is a qualitatively new information product that combines reliable data and tools for analysis, visualization and data management of a professional GIS system. These tools include attribute reports, a variety of thematic displays, informative pop-ups, dynamic charts, time sliders, template-based smart data collection, and geostatistics and geoprocessing.

As an addition, a special interface was created for the convenience of using the card not only on a personal computer or laptop, but also when using smartphones or tablets.

There was also a built-in function for printing the map in various formats by pressing the special symbol "print" and available navigation on the map for personal choice of the angle, approach or distance. In addition, such tools for working with the map have been added, such as switching layers on the map, choosing the type of basemap and the ability to share this map with other users.

4. MEASURES FOR MANAGING PASTURE RESOURCES WITH VARYING DEGREES OF DEGRADATION BY GEOGRAPHIC ZONES OF KAZAKHSTAN

4.1 IV-Degree of Degradation (Failure)

This activity is carried out in accordance with the recommendations for the radical improvement of pastures with the creation of seeded pastures. Fundamental improvement is a rather costly measure and it should be carried out only on those degraded downed pastures, which, according to the survey results, have lost their ability to natural regeneration.

There are 27.1 million ha of such degraded pastures in Kazakhstan. The procedure and list of work on the radical improvement of degraded pastures are detailed in the zonal recommendations available in each region. The manual presents the main elements of activities in a zonal aspect.

- Forest-steppe zone. The forest-steppe zone includes the North Kazakhstan region. According to statistics, there are 468 thousand hectares of knocked down pastures (IV - stage) of degradation in the zone. Table 1 shows the recommended interventions for the forest-steppe zone, the soil cultivation technique, recommended crops, rates, sowing methods and timing.

Table 1: Recommended Measures for the Forest-Steppe Zone

Indicators	Activities
Soil preparation	by the type of moldboardless steam, processing depth 18-20cm. In the spring, it is necessary to carry out disking, followed by rolling the soil and sowing
Recommended cultures for improving soil	Alfalfa, Onobrychis, Bromus Inermis, wheatgrass and their mixes
Norms of sowing. Net crops, kg / ha	alfalfa - 12, Onobrychis - 70, Bromus inermis - 25-30, wheatgrass - 14-16. Net crops, kg / ha
Depth of planting seeds, cm	alfalfa, Bromus, wheatgrass-2-3, Onobrychis-4-5
Method of planting	continuous row sowing with 15 cm row spacing without cover with post-sowing packing
Terms of sowing	Spring (beginning of May or end of June)

- Zone of steppe and dry steppe. The steppe and dry steppe zone includes the West Kazakhstan, Kostanay, Aktobe, Karaganda, Pavlodar, East Kazakhstan, Akmola regions. In the zone there are 10649 thousand hectares degraded (IV-stage of degradation) pastures. Table 2 shows the recommended actions for the steppe and dry steppe zone, the soil cultivation technique, recommended crops, rates, sowing methods and timing.

Table 2: Recommended Measures for the Steppe and Dry Steppe Zone

Indicators	Activities
Soil preparation	moldboard plowing to a depth of 18-20 cm, or processing with a disc harrow (or a similar tool) to a depth of 15-18 cm. The soil is prepared by the type of fallow or early plowing. On lands with a danger of wind erosion, strip placement of crops with a width of no more than 50 m located across the prevailing winds is used.
Recommended cultures for improving soil	alfalfa blue and yellow, sandy Onobrychis, Leymus, wheatgrass wideleaf and thinleaf, Bromus inermis.
Norms of sowing Net crops, kg / ha	alfalfa -8-10, Onobrychis- 40-45, wheatgrass- 10-12, Leymus- 7-10, Bromus inermis-12-14.
Depth of planting seeds, cm	alfalfa, Leymus, Bromus, wheatgrass – 2-3 cm, Onobrychis – 4-5 cm.
Method of planting	continuous row sowing with 15 cm row spacing after sowing packing. A hairline can be sown with a row spacing of 30-45 cm.
Terms of sowing	early - spring, with the first opportunity to begin field works

- Saline lands. More than 60 million hectares of solonetzes or solonetz complexes are used for grazing animals. Measures to improve pastures on such lands have their own characteristics.

Table 3 shows recommended actions for alkaline soils, the soil cultivation technique, recommended crops, rates, sowing methods and timing.

Table 3: Recommended Measures for Alkaline Aoils

Indicators	Activities
Soil preparation	moldboard processing by the type of steam to a depth of 30-35cm, processing with a disc harrow and 2-fold soil harrowing and sowing.
Recommended cultures for improving soil	Melylotus, Leymus, alfalfa, wheatgrass, couch grass, winter rye as a predecessor culture
Norms of sowing Net crops, kg / ha	on solonetzs, the seeding rates of perennial (two-year) grasses are increased by 25% compared to zonal soils: alfalfa - 12,5, Melylotus - 12,5, Leymus – 12,5, wheatgrass – 15,0, couch grass – 17,5, winter rye – 80-100.
Method of planting	early-spring, with the first opportunity to start field work. Winter rye - 1st decade of September.
Terms of sowing	solid row with spacing of 15 cm, Leymus - with a row spacing of 30 cm.

It is recommended to apply manure for the main tillage at the rate of 40 t / ha.

- Arid pastures. Semi-desert and desert zone. Kyzylorda, South Kazakhstan, Zhambyl, Almaty, Atyrau, Mangystau regions, there are 14674 thousand hectares of degraded pastures. Table 4 shows recommended actions for semi-desert and desert zones, the soil cultivation technique, recommended crops, rates, sowing methods and timing.

– On clay soils:

Table 4: Recommended Activities for Semi-Desert and Desert Zones

Indicators	Activities
Soil preparation	moldboard processing depth 20-22 cm according to the principle of steam or plowing, harrowing with simultaneous packing. With a small humus soil layer, it is necessary to perform non-moldboard tillage to a depth of 15-18 cm.
Recommended cultures for improving soil	wheatgrass, Kochia, Salsola, Camphorosma, Pamiran winterfat, sagebrush, Haloxylon, Salsola subaphylla, Salsola Richteri
Norms of sowing Net crops, kg / ha	wheatgrass – 15, Kochia-15, Salsola-8, Camphorosma-6, Pamiran winterfat-20, sagebrush-4, Haloxylon-10, Salsola subaphylla-10, Salsola Richteri-12, in regard to 100% farming usage.
Method of planting	all of the listed improver plants are sown in the period November-January.
Terms of sowing	all of these plants are sown for 0.5-1.5 cm for seeding into the soil. Seeding is done after sowing by rolling with ring rollers.
Soil preparation	continuous row sowing, Haloxylon, Salsola subaphylla and Salsola Richteri with row spacing of 45-60 cm. Sowing is carried out with a special SST-3 seeder and SZT-3,6 seeder

- on sandy pastures:

Unlike agricultural techniques for improving degraded pastures on clay soils, in sands, tillage is reduced to surface loosening of the soil to a depth of 10-12 cm. The width of cultivated strips is 5-6 m, alternating with untreated strips of a similar width. The rest of the elements of agricultural technology are similar to agricultural activities on clay soils.

4.2 III-Degree of Degradation (Strong Degradation)

On pastures where there was a strong grazing of herbage, dominants and subdominants of the plant community have not yet lost their generative ability (III - degradation stage), it is recommended to introduce a three-season four-year pasture rotation scheme with alternating plots. The load on the pasture is 10% lower than the calculated one. The grazing rate is up to 60% of the total pasture mass. Table 5 shows four plots of three-season pasture rotation.

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Table 5: Schedule of Using Pasture sites by Year

Year	Terms of usage			
	1st site	2nd site	3rd site	4th site
1st	spring	summer	autumn	idle
2nd	idle	spring	summer	autumn
3rd	autumn	idle	spring	summer
4th	summer	autumn	idle	spring

According to Table 5, it should be noted that in some areas where there are pastures with sparse grass, it is necessary to re-sow valuable forage grasses, i.e. it is necessary to carry out surface improvement of pastures. With surface improvement, the existing natural vegetation of the forage area is partially changed. On such forage lands, the biodiversity of grass stands increases, while the quality of forage improves and the productivity of pastures increases. Surface improvement of these lands is carried out as follows:

- Forest-steppe zone, North Kazakhstan region, (Table 6), the soil cultivation technique, recommended crops, rates, sowing methods and timing.

Table 6: Recommended Measures for the Forest-Steppe Zone

Indicators	Activities
Soil preparation	tillage with a disc harrow to a depth of 8-10 cm with harrowing angle of 15^0. Sowing should be done with a disc seeder, which ensures penetration of seeds into the soil
Recommended cultures for improving soil	alfalfa, Onobrychis, Bromus inermis, wheatgrass broad-headed and mixtures thereof. On pastures, it is better to use two or three component mixtures
Norms of sowing Net crops, kg / ha	alfalfa - 8, Onobrychis - 50, Bromus inermis - 17-21, wheatgrass - 10-11, When sowing herbs in mixtures, the seeding rate of each crop is reduced by half of the norm
Method of planting	alfalfa, Bromus, wheatgrass-2-3, Onobrychis-4-5
Terms of sowing	continuous row sowing with 15 cm row spacing, without cover with post-sowing packing
Soil preparation	spring (early May or late June)

- The steppe and dry steppe zone include the West Kazakhstan, Kostanay, Aktobe, Karaganda, Pavlodar, East Kazakhstan, Akmola regions, (Table 7), the soil cultivation technique, recommended crops, rates, sowing methods and timing.

Table 7: Recommended Measures for the Steppe and Dry Steppe Zone

Indicators	Activities
Soil preparation	tillage with a disc harrow to a depth of 8-10 cm with harrowing angle of 15^0. Sowing should be done with a disc seeder, which ensures penetration of seeds into the soil
Recommended cultures for improving soil	alfalfa blue and yellow, sandy Onobrychis, Leymus, wheatgrass wideleaf and narrow-leaf, Bromus inermis
Norms of sowing Net crops, kg / ha	alfalfa - 6-8, Onobrychis - 30-40, wheatgrass - 8-10, Leymus - 7-10, Bromus inermis - 10-12. When sowing herbs in mixtures, the seeding rate of each crop is reduced by half of the norm
Method of planting	alfalfa, Leymus, Bromus, wheatgrass - 2-3 cm, Onobrychis - 4-5 cm
Terms of sowing	continuous row sowing with 15 cm row spacing, without cover with post-sowing packing
Soil preparation	Leymus can be sown with a row spacing of 30-45 cm. Early-spring, with the first opportunity to start field work

- Semi-desert and desert zone, Kyzylorda, South Kazakhstan, Zhambyl, Almaty, Atyrau, Mangystau, (Table 8), the soil cultivation technique, recommended crops, rates, sowing methods and timing.

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Table 8: Recommended Activities for Semi-Desert and Desert Zones

Indicators	Activities
Soil preparation	tillage with a disc harrow to a depth of 4-6 cm with harrowing angle of 15^0. Harrowing should be done on sandy soils. Sowing should be done with a disc seeder, which ensures penetration of seeds into the soil
Recommended cultures for improving soil	wheatgrass, Kochia, Salsola, Camphorosma, Pamiran winterfat, Haloxylon, Salsola subaphylla, Salsola Richteri
Norms of sowing Net crops, kg / ha	wheatgrass – 12, Kochia -12, Salsola - 8, Camphorosma - 6, Pamiran winterfat - 16, sagebrush - 4, Haloxylon - 10, Salsola subaphylla - 10, Salsola Richteri - 12, with regard to 100% farming usage
Method of planting	all of the listed plants are sown with a depth of 0.5-1.5 cm for seeding into the soil. The seeding is done after sowing by rolling with ring rollers
Terms of sowing	continuous row sowing, Haloxylon, Salsola subaphylla and Salsola Richteri with a row spacing of 45-60 cm. Sowing is carried out with a special SST-3 seeder and SZT-3.6 seeder
Soil preparation	all the listed plants - improvers are sown in the winter and winter periods, November-January

4.3. II- Degree of Degradation (Medium Degradation)

When improving pastures, with such a degree of degradation, it is necessary to use a three-season, three-year pasture rotation with the obligatory use of intra-seasonal pasture rotation, (Table 9).

Table 9: Three-Year Three-Season with the Use of Intra-Seasonal Pasture Rotation

Year	Seasons and terms of using pastures								
	Spring pasture			Summer pasture			Autumn pasture		
	I-section	II-section	III-section	I-section	II-section	III-section	I-section	II-section	III-section
1st	Start	Middle	End	Start	Middle	End	Start	Middle	End
2nd	Middle	End	Start	Middle	End	Start	Middle	End	Start
3rd	End	Start	Middle	End	Start	Middle	End	Start	Middle

Table 9 shows that, each seasonal pasture area is divided into three areas, and cattle grazing is carried out sequentially, i.e. livestock on the seasonal pasture is grazed first on the first plot, and then transferred to the second and then to the third plot, and then it moves to the summer pasture. The following year, grazing starts at the second site and ends at the first site. The same division of plots is carried out on summer and autumn pastures. The load on the pasture is lower than the calculated one - by 10%. The grazing coefficient is 60% of the pasture mass.

In areas with sparse grass stand - provision of rest for 1-2 years. Such improvement of pastures with a moderate degree of degradation is applicable in all zones of Kazakhstan.

4.4 I - The Degree of Degradation (Weak Grazing)

With this degree of degradation, a three-season, three-year pasture rotation should be used to improve pastures. The load on the pasture is optimal, the utilization rate of herbage is 70% of the total mass. The use of pastures is once a season, (Table 10). This table shows the timing of pasture use and rotation by year and by plot.

Table 10: Three-Seasonal Three-Division Pasture Rotation

Year	Terms of usage		
	1st site	2nd site	3rd site
1st	spring	summer	autumn
2nd	summer	autumn	spring
3rd	autumn	spring	summer

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5. DISCUSSION

In 2015-2017, the Kazakh Research Institute of Livestock and Fodder Production conducted research on the development of technology for improvement and rational use of pastures for the development of distant pasture production with the measure of sustainable management of pasture resources using GIS technologies. As a result of field research and digital technologies for the first time a database of pasture resources of Kazakhstan was compiled including the following indicators: botanical composition of herbage, classes and types of pastures, their yields, fodder reserve in air-dry mass and fodder units, pasture watering, pasture load, etc. Digital cartographic models in M 1:1,500,000 on the basis of modern GIS technology, which is now the main tool for sustainable management of pasture resources in Kazakhstan, have been prepared. On this basis the KazNII of cattle breeding and fodder production created a GIS-portal "Pasture resources of Kazakhstan" [3].

According to the results of research conducted at the Kazakh Research Institute of Livestock and Fodder Production the digital map on sustainable management of pasture resources of Kazakhstan, covers the technology of improvement and rational use of pastures not prone to degradation, given that in Kazakhstan more than 50% of pastures of the total area of 186.4 million hectares are degraded [21].

Therefore, our developed interactive geoinformation map of degraded pastures in Kazakhstan allows us to give a complete picture of the state of these pastures, the results of which were digitized, which is a great contribution to the digitalization of livestock development in Kazakhstan, consistent with the program "Digital Kazakhstan".

The difference of the conducted research from the previous works is that there are no scientific and practical provisions on management and monitoring of degraded pastures based on digital technologies in Kazakhstan. This development will allow determining the location of such lands by the degree of degradation in the desert, foothill semi-desert (vertical), semi-desert (latitudinal), dry-steppe, steppe and forest-steppe zones. Besides, development of cartographic model of degraded rangelands taking into account degrees of degradation makes it possible (taking into account soil and climatic conditions) to develop optimal options for their restoration (improvement) with subsequent preservation of productive longevity.

The limitations of research methods can be considered the main advantage of the scientific way of studying various phenomena. The quantitative limitation of these studies is determined by the limitation of the research period (3 years), and pastures have a long period of use. The qualitative limitation of research does not include the study of livestock productivity in the studied pastures and the impact of grazing on pasture degradation.

6. CONCLUSION

1. Carried out at 33 monitoring sites of grazing lands of settlements of desert, foothill semi-desert (vertical), semi-desert (latitudinal), dry-steppe, steppe and forest-steppe zones of the Republic of Kazakhstan showed almost everywhere their degradation, especially desert and semi-desert (latitudinal) zones. At the same time, the degree of degradation of pastures increases as it approaches settlements, which is quite natural, since rural residents, due to their poor wealth, cannot use spur pastures. It should be noted that the climatic features of these zones are low rainfall and high average annual temperature.

2. The analysis of the NDVI growing index of the desert, foothill semi-desert (vertical), semi-desert (latitudinal), dry-steppe, steppe and forest-steppe zones of the republic for 2018-2020 confirms the degradation data obtained by terrestrial studies. The noted decrease and increase in VI values are characterized by average overgrazing of livestock, vegetation features of plant communities, soil and climatic conditions. On the basis of the established database, which includes ground survey data and medium and low resolution satellite information, maps of the degradation of pastures of all the above zones were built, which were the basis for the development of a geographical information map of the degradation of pastures of all territories of Kazakhstan.

3. A database on all soil-geographical zones was compiled, including the following indicators: by physical indicator - soil type, morphology, granulometric composition, content of humus, nutrients, sum of absorbed bases, content of water-soluble salts in the soil layer 0-30 cm, according to the biological indicator - botanical composition, species composition of grass, yield and projective coating of soil with vegetation.

4. An interactive geoinformation map of the degree of pasture degradation has been developed for all soil and geographical zones of Kazakhstan at a scale of 1: 750 000, which includes soil, botanical characteristics and measures for their management.

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