WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR AGRICULTURAL METEOROLOGY

CAgM Report No. 96

IMPACT OF AGROMETEOROLOGICAL INFORMATION ON RANGELAND AND PASTURE ECOLOGY AND MANAGEMENT

Prepared by
L. V. Lebed (Co-ordinator), Y. Gandega, D. Rijks

Report of the Joint Rapporteurs on Impact of Agrometeorological Information on Rangeland and Pasture Ecology and Management

WTO/TD No. 1229
Geneva, Switzerland

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CONTENTS

Foreword

This report was prepared under the provisions of Resolution 11 of CAgM-XII relating to the appointment of Joint Rapporteurs on the Impact of Agrometeorological Information on Rangeland and Pasture Ecology and Management. It is a continuation of a series of reports of the CAgM that describe aspects of agrometeorological services for pasture production and livestock. The most recent of these reports were prepared by: Sivakumar M.V.K., Renard C. and Powell Y.M., 1992, Agroclimatical Considerations for Sustainable Agro-Silvi-Pastoral Systems in the Sudano-Sahelian Zone; Danielov S. A., Gringof I. G.and Germogenov M. T., 1995, The Definition of Agrometeorological Information necessary for Management of Pasture Production and Livestock Production in the Cold Climatic zone; Dagvadorj D., 1998, Weather and Climate Related to Pasture and Livestock Production in Arid and Semi-Arid region; Babushkin O.V. 1998. The Use Meteorological Information necessary for the Industry of Pasture and Livestock Production in Arid and Semi-Arid Climatic zone; L. V. Lebed, 1998, Use of Direct and Remote Sensing Me thods to Provide Information for Livestock and Pasture Production in the Arid climatic zone (as illustrated by the experience of Kazakhstan) and others.

The continued study of this theme is of current interest because the condition of pastures and rangeland is deteriorating in many parts of the world. The first cause is the increasing pressure of the human and animal populations in pasture areas. The influence of climate change and of the greenhouse effect on pasture ecosystems also needs to be studied. These phenomena may cause an increase of desertification in pasture areas in arid and semi-arid zones. Part 1 of this report presents summaries on the use of agrometeorological data for the management of pastures in difference natural zones and economic conditions. Part 2 describes estimates of possible influences of climate change on pasture ecosystems in Kazakhstan. A detailed report on the activities described in section 1.2.1. was foreseen to be given in this report to CAgM, but due to unforeseeable circumstances the field activities could not be carried out as planned.

For the collection of information from other countries, a questionnaire was sent to Members of WMO (Annex 1). The authors thank the colleagues that answered the request for information. The names of these authors are given in the table of contents.

The report was prepared by the coordinator of the joint reporters, L. Lebed, Kazakh Scientific and Research Institute for Environment and Climate Monitoring of the State Enterprise "Kazhydromet", in collaboration with Y. Gandega, Ministry of Agriculture and Rural Development, I.R. of Mauritania, and D. Rijks, Agrometeorological Applications Associates, France.

1. Summaries of the impact of agrometeorological information on rangeland and pasture ecology and management in different climatic regions

1.1 Temperate and cold climatic regions

1.1.1 Russian Federation

Suitable land for cattle grazing is found in all soil-climate zones of the Russian Federation: in the tundra, forest-tundra, wood, forest-steppe, steppe, and semi-arid areas.

Table 1. Agroclimatic characteristics of the zones (U. Chirkov and B. Ohorodnikov)

Zone	Days with temperature > 10°C	FAR for periods >5°C, MgJ/m^2	Sum active temperature, °C	Temperature of July, °C	Precipitation for the year, mm	Evapo-transpiration for the year, mm
Tundra, forest-tundra	120-165	754-905	0-800	0-15	200-500	240-360
Forest	138-248	1030-1550	900-2550	14-21	250-650	300-550
Forest-steppe	164-248	1257-1676	1300-2850	17-21	300-600	350-705
Steppe	192-275	1592-2011	2200-3500	20-24	250-550	550-765
Semi-arid	203-229	1760-1886	2600-3400	22-25	175-250	650-850

The natural vegetation of these zones provides the basic supply of energy to agricultural animals during the warm period of year. The animals must be stall-fed during the cold months of year. The productivity of vegetation apt for pasturing animals varies from year to year as a function of the development of agrometeorological conditions.

Table 2. Short characteristic of pastures in different natural zones (I. Gringof, 2000)

Natural zone	Area of pasture, %	Mean biomass, t/ha	Pastures period, days
Tundra, forest-tundra	90-95	0,05-0.25 in tundra and 0,3-1,0 in forest-tundra	All year
Forest	4	Meadow 0,7-1,0 Moist places 1,2-2,0	130-140
Forest – steppe	15	Meadow: from 0,6-0,8 to 2,0-2,5; pasture 15-20	150-200
Steppe Semiarid	40 70	Meadow: 10 Pasture: 0,2-2,5 about 0,4	180-200 220-270

The criteria to assess the security of the forage production in all periods include: the minimal daily need for energy of 1 standard unit of large horned cattle, the average caloric value of 1 kg of a specific forage, the number of heads of cattle, the productivity of the vegetation apt for pasturing and the duration of the grazing and stall-feeding periods. The influence of the pressure of the human population at a local level is also taken into account. Decisions, for economic reasons, on rotation in pasture areas are if necessary accepted.

The agrometeorological information is assembled and processed at regional hydrometeorological centers and transferred to regional agricultural divisions, and hence to further users. The basic data collected by field surveys and meteorological stations include: air temperature, precipitation, the condition of pasture vegetation (phase of development, height, productivity), warnings for dangerous hydrometeorological conditions, etc. The spatial scale on which information is prepared depends on the scale required by the consumer (from the farmer up to management authorities of the country).

At the regional and farmer levels economic measures will be carried out to improve poor or degraded pastures (the sowing of fodder grass, destruction of bush, drainage, irrigation), and to create new pastures on large areas, with annual crops and perennial fodder grass and other species. Agrometeorological information is given on inquiries made by consumers. For estimates of the conditions of growth, development and the productivity of grass and natural pasture vegetation, physical-statistical models are used, including methods to forecast their productivity with a 1 to 2 months outlook. The success of these quantitative estimations and forecasts has been high. The resulting information is published in ten-day agrometeorological bulletins and appropriate reviews by the Hydrometeorological Center of Russia and regional HMC and delivered to the regional consumers.

For the preparation of the present material the following literature was used:

- M. Kolos, 1974, Pastures and haymaking USSR, 512 pp.
- V.A. Zhukov, S.A. Danielov, 1998, About the account of agroclimatic resources of Russia in a task of specialization of agricultural manufacture. M. " Meteorology and hydrology ", ? 6, p. 92-99.
- I.G. Gringof, A condition and ways of perfection of agrometeorological supervision of pastures and haymaking in the Russian Federation, Works of VNIISChM, Issue 32, S-Peterburg, Hydrometeoizdat, p.12-32.
- I.G. Gringof, Droughts and desertification - ecological problems of modernity(present). Works of VNIISChM, Issue 33, Hydrometeoizdat, p. 14-40.

1.1.2 Canada (western)

Western Canada has close to 18.2 million hectares of native rangeland and close to 2.5 million hectares of improved pastures seeded to introduce species. Precipitation ranges from 250 mm to 550 mm per year with peak precipitation during the summer months. Temperatures range from +40°C to –40°C and the active growing season lasts from May 15 to September 15. Grazing on stockpiled forages often continues into mid-November. Both native range and pastures range from being excellent to poor, the condition depending on a number of factors such as stocking rates, carrying capacity, climatic conditions, etc.

The following paragraph describes the kinds of livestock that prevail on each type of rangeland pasture, the grazing systems, and both the charge of livestock and the carrying capacity indicating whether the charge is less than, equal to, or greater than the carrying capacity. It specifies other kinds of man-made impacts on the pastures.

Beef cattle are most common in western Canada, with >80% of Canada's beef herd, however, sheep and horses are commonly seen on pastures. Bison and elk are also becoming more common. Smaller framed British breeds (e.g. Hereford, Angus, Shorthorn) of cattle are most common where biomass production is low, in low rainfall areas, and larger framed European/British crossbreds or pure European breeds (e.g. Charolais, Simmental, Limousin) are more common where pastures are more productive, in high rainfall areas. In native pasture areas pastures are either grazed season long or a complementary grazing system is used to provide grazing in the spring and thus allow native pastures an opportunity to grow before grazing starts. This strategy has improved the productivity of native pastures substantially. In seeded pastures in productive environments more intensive management is used. Often pastures are subdivided with electric fences and rotational grazing is practiced but sometimes these pastures are grazed season-long. Generally stocking rates are less than or equal to carrying capacity. Carrying capacity ranges from 1 cow-calf pair per hectare to 1 cow-calf pair per 25 or more hectares depending on the rainfall zone and whether fertilizer is used. Major problems are related to brush invasion in pastures due to control of fires (a historically significant factor in grassland ecology), and to exotic invader species of weeds.

Temperature and precipitation are the most commonly used agrometeorological information for the exploitation of pastures and in the industry of livestock production. However, the impacts of other extreme weather events (drought, frost, hail, tornados) are often needed to assess crop insurance claims. Recently some researchers are developing plant growth models that run using daily climate data. Such data can also be used to model the impacts of climate change on the economy. This may allow science to develop ways to mitigate the effects of climate change.

To improve the pastures and the areas used for grazing of livestock, climatic information and soil type data have been used to determine carrying capacities on government land, which is leased to ranchers. These grazing leases are monitored to prevent overgrazing. The information is used by cattlemen in setting stocking rates on their own land; however stocking rates on privately owned lands are not monitored. Government extension programs are used to educate farmers regarding proper stocking to prevent damage to the pasture/range resource.

Sustainable use of the pasture resources is of direct benefit to farmers and ranchers at a social, economic and ecological level. More productive pastures mean more productive livestock, which means more profitable farmers and ranchers in the short term. More productive ranges and pastures in the long term results in better ecological conditions. The availability of agrometerological data allows pasture and range productivity to be modeled and managed. There can not be management without measurement.

Bibliography

- S. Smoliak, M.R. Kilcher, L.W. Lodge, A. Johnston, 1982, Management of Prairie Rangeland, Publication 1589, available from the Communications Branch, Agriculture Canada, Ottawa KIA OC7.

1.1.3 Canada (other areas)

Most of the Parkland and Tallgrass Prairie in the Northern Great Plains has been cultivated for forage and crop production rather than being grazed. Irrigation has been practiced in the southern prairie and grasslands have been cultivated in the north and east, on the Dark Brown and Black Chernozemic soils. No specific information on the changes in agrometeorological conditions has been documented.

The method of exploitation is, basically, cow-calf season-long grazing on native pasture with some specialization with respect to seasonal pasture and rotational grazing for specific personal or environmental objectives. Seeded pastures are more intensively managed and may include stockpiling forage for winter use, creep feeding and rotational grazing. Most privately owned rangeland tends to be overgrazed but publicly owned range is managed for good condition. Stocking rates on good-condition native range vary from about 12 animal-unit-months (AUM) per ha in the north to 1.8 AUM/ha in the south. Irrigation can boost the stocking rates to 18 AUM/ha.

Cumulative precipitation is an important weather element used by the crop insurance agencies. For example, in the province of Alberta, the Agriculture Financial Service Corp uses precipitation to predict production losses. In fact the Alberta provincial government have purchased insurance for agriculture based on receiving a certain amount of precipitation in regions. Average annual precipitation (combined with soil factors) has been used to set stocking rates on a regional basis. This information is also used by the provincial algologists who may set stocking rates for grazing associations or set premiums for insurance purposes. Other use of agrometeorological information includes making forecasts on the activity of grasshoppers and other insects that are based on temperature and precipitation. Further details can be found on the following site:

http://res2.agr.ca/lethbridge/lscitech/dlj/background.htm

A contribution to the session documentation, "Application of geographic information system technology in forecasting grasshopper outbreaks", was made by Johnson et. al. at the Joint Meeting of the World Meteorological Organization, European Plant Protection Organization, and North American Plant Protection Organization, Florence, Italy, Dec 1990, 2 pp.

Other government projects are investigating soil moisture and drought modeling of grassland and water availability, from runoff, for cattle on grassland. These projects are funded by the Alberta and Canadian governments for water and pasture managers.

Social, economic and ecological benefits are based on whether the pastures are native or cultivated. On native pasture improvements will be achieved by restocking. Some fences may be constructed to enhance environmental values and, in some cases, to improve forage utilization. Seeded pastures are commonly overgrazed and reseeded as required. More intensive operations will use annual pastures with creep feeding or zero grazing. Actions towards improvements of these systems are based on knowledge of the state of range and pasture, and of precipitation totals.

Other benefits are related to crop insurance, setting stocking rates and use and possible reduction of insecticides in controlling outbreaks.

1.2 The arid and semi-arid climatic regions

1.2.1 I. R. of Mauritania

The development of and changes in pastures in Mauritania depend on the spatial and temporal distribution of precipitation and the nature of the soil and its rate of infiltration. Consequently, there are two possible scenarios:

1. Rainfall is irregular with long intervals. Vegetation appears ten days after the initial rainfall and then dries out. Once these first seedlings have dried out, the problem of insufficient naturally-occurring seeds arises.

2. Rainfall is regular and evenly distributed. Vegetation mainly consists of grass which grows normally. The pastures are rich and could provide good forage reserves.

Mauritania uses a migratory herding system. The dominant species are camelidae, bovidae and caprines. Camelidae and caprines are found mainly in aerial pastures during the dry season, whereas bovidae prefer grassy pastures. Pastures are often damaged by bush fires and by the over-abundance of livestock in geographically restricted areas.

In order to provide livestock farmers with agrometeorological data, test sites have been selected in mutual agreement with veterinarians working in the field, within the framework of a multidisciplinary working group (MWG). Sixteen sites have been identified in agropastoral areas. In cases of poor forage provision, the following advice is given: the use of supplementary foods when appropriate, the use of agricultural by-products and the drawing up of forage maps indicating watering places and encouraging livestock farmers to migrate to other areas.

With a view to improving pastures, extension work with livestock and agricultural farmers is required so as to prevent bush fires, preserve forage reserves, encourage the State to take the necessary measures for establishing firebreaks where necessary, and indicate migration routes and resting areas. Vegetation index maps are used in Mauritania and provide an effective means for monitoring and assessing pastures.

The user benefits of this agrometeorological information are:

1. Cattle may be kept close to settlements for as long as possible to prevent premature migration.

2. Livestock farmers can avoid making long trips to sell their produce (milk, meat, leather, etc.).

3. Family cohesion is maintained, by reducing the period that the head of the family moves to summer pastures with the cattle, leaving the rest of the family behind.

1.2.2 Ethiopia

Ethiopia lies within the tropics of eastern Africa between latitude 3°N and 15°N and longitude 33°E and 48°E. About 70% of total land area of the country has an arid or semi-arid climate. For centuries pastoralists and sedentary farmers, whose livelihood depends mainly on livestock and livestock products, have inhabited most of these areas. Although not, so far, influenced by agro-meteorological information, changes are underway and seasonal, monthly, and ten-day meteorological forecasts have helped to provide information on the expected conditions in agro-pastoral areas, and thus on the grazing pasture for livestock.

In most of the agro-pastoral areas of the country the kind of livestock that prevail are cattle, sheep, goats, camel, horse, mule, donkey etc. The grazing system practiced by the inhabitants is to exploit any region with sufficient water and pasture until it becomes necessary to move to find anew access to water and pasture following the dry season. Most of the rangelands are overstocked, though the exact figure is difficult to ascertain.

The national meteorological services agency of Ethiopia produces ten-day, monthly and seasonal agro-meteorological information in addition to meteorological bulletins. The information in these bulletins includes agro-meteorological assessments, actual weather assessments and a weather outlook. Although not practiced at present, these bulletins used to produce vegetation and rainfall assessment based on satellite remote sensing. Such practice has been suspended due to technical problems with the satellite reception systems.

Agro-meteorological information and services could improve pasture and livestock management on rangeland and adjust the grazing systems in accordance with their herd size, in a number of ways. The information includes a) a forecast of moisture indices b) outputs of satellite remote sensing on vegetation (normally NDVI) and rainfall conditions that assist in early warning activities (because in most of these areas the traditional type weather / meteorological stations are unavailable) and c) information to be broadcasted to pastoralists in their local languages via satellite digital radio, easily available because most pastoralists move in community groups.

Overstocking and the increased frequency of return to the areas have generated the present overall ecological conditions of the rangelands of Ethiopia.

The agrometeorolgical and meteorological assessments provided by the agency are corner stones for the disaster prevention and preparedness activities, which have been carried out in the country. In general experts of the agency participate in the crop and pasture assessments that are carried out regularly at the national level and contribute to the famine early warning system in the country.

1.2.3 Israel

On the Mediterranean grasslands, cattle, sheep and goats, are grazing only in the wet season, from November to April. Precipitation in the rainy season varies with location from 200 to 800 mm/year.

Beef cows (mothers and sucking calves) are grazing mainly in mountainous regions where no alternative for cultivation exists; in these regions there is also grazing for sheep (meat and milk) and goats.

Rainfall indexes are provided to farmers to predict pasture production and a possible prolongation of the grazing period.

Improvement of pastures is done by seeding the land and by fertilization before the growing season and by killing bad vegetation at the end of growing season. The agro-meteorological information used includes: rainfall, wind velocity and wind direction.

The presence of grazing animals conserves the land, supplies some meat and milk for local consumption, prevents erosion, and helps to maintain a divers population in the peripheral areas of the country.

The variability of the rangeland used in Israel for grazing by livestock is very large, depending on the region. The dry southern Negev normally gets 130-200 mm/year, and is characterized by grasses and other typical desert vegetation. The high area in the rainy northern part of the country, receiving 500-800 mm/year, is characterized by forest and bush vegetation.

The pasture can be used either for beef cattle, mixed animal populations, or sheep and goats. The heterogeneity of the landscape is the main factor determining the carrying capacity in each region.

As an example, the Golan Heights in the north of the country, a rainy and cool area, has a high carrying capacity and thus is a good area to raise cattle. The warm and arid lowlands at the south of the country have a low carrying capacity and few cattle are raised there.

The main climatic elements that have an effect on the exploitation of pastures and in the livestock industry is: temperature, rainfall and humidity. The main effects are on the composition and quantity of the pasture vegetation. The meteorological service is the main source of the data, mainly, but not only, by the issue of a ten-day agro-meteorological bulletin. Throughout the year the bulletin contains daily and ten-day values and normals of the data, as well as cumulative data and indices. The information is disseminated to subscribers of the bulletin, mostly professionals of the ministry of agriculture, including instructors, planners and researchers. Individual farmers and food producing factories are also subscribers.

Relevant meteorological information is available on the Internet site of the Israel Meteorological Service. Some current data are taken directly from stations that are located in agricultural areas and are jointly managed by the meteorological service and the ministry of agriculture. Some meteorological information is available also on the Internet site of the Ministry of Agriculture.

Various methods for pasture improvement and managing the areas used for grazing are used in Israel. There are 2 methods aiming to destroy, or at least reduce, the undesirable vegetation: mechanical methods and spraying. Fertilizing is used to enhance the desired vegetation. Re-sowing of the desired vegetation is also in use.

The following benefits can be obtained by using agro-meteorological information: the selection of the growing areas according to their climatic potential; and the optimal choice of the different types of livestock in each area.

1.2.4 I.R. of Iran

As a function of its types of vegetation, rangelands are put into three classes (TOR, 2000):

Type	**Good–fair**	**Fair–poor**	**Poor–very poor**	**Total**
Area (10^6 ha)	14	60	16	90

Unfortunately, the ratio of the area in each of the classes of rangelands has drastically changed for the worse, because of drought and increasing pressure on the grazing area. An analysis of 32 years' climatic data of the country reveals that the mean annual rainfall of the last 17 years is lower than the long-term average (TOR, 2000).

The prevailing kinds of livestock are: sheep, goats, native cattle, hybrid cattle, pure breed cattle, camel, and buffalo. As an example of the charge of livestock, 530 hectares of land are being grazed by 229 A.U. over a period of 8 months at the Faculty of social science of Tehran University. Overgrazing is the most important problem of the rangelands in Iran, because the livestock population is more than 5 times greater than the carrying capacity.

In Iran forest and range organizations often use precipitation data, e.g. to assess:

- The effect of severe drought on the elimination of the vegetation cover, evident all over Iran: in the Touranian, Khalidj, Ommanian and Zagross regions.
- Flooding in wet years, the result of depleted rangelands, resulting in erosion and destruction of fertile soil.

As an important step toward land rehabilitation, grazing rights are given to the households that traditionally possessed the land and now use it as rangeland by means of a grazing license. The grazing license shows the boundary of the land, the owner(s) of the land, the grazing period and the number of animals they can keep to graze on the land. So far 56.4 million hectares of rangelands have been inventoried and grazing licenses for these have been issued.

Among the uses of agro-meteorological information are the forecasting of crop/pasture production, minimum temperature and associated crop risks, agroclimatological recommendations etc. All of these can lead to increased crop/pasture production that can improve social and economic conditions.

Reference:

TOR, 2000, Technical Office of Rangelands, Iran forest and range organization

1.2.5 Jordan

In Jordan for grazing by livestock used the kinds rangelands:

- short grass, short grass and small shrubs, both kinds are highly degraded, climatic changes such as increasing rainfall contributed to the deterioration of vegetation cover, such changes had negative impact on livestock production.

Kinds of animals, that prevail on each type of rangeland or pasture:

- mostly sheep and few cows,
- grazing system – open ranges,

- carrying capacity is estimated of 4 sheep,
- current number exceed the carrying capacity.

Human activities such as plough, traffic movement and shrubs cutting inflict negative impact on the rangelands.

For the exploitation of pasture and in the industry of livestock production used temperature, rainfall data,

- The med data are generally used in planning project and in research projects.
- Measures to rehabilitation ranges are:
- plantations suitable plants with participation of local communities,
- establishment of range grazing areas,
- rangeland development using water harvesting techniques.

Ecological characteristics of pasture are:

- determine plant adaptation,
- calculation of crop water requirement,
- prediction of disease incidents,
- identification of plant species suitable for different ecological systems.

1.2.6 Kingdom of Saudi Arabia

The rangelands in the Kingdom of Saudi Arabia consist of dwarf shrub dominants, annual rangelands with ephemeral species and steppe vegetation with Accacia species as over story and tall grasses like panicum and penesitum sp.

Sheep, camel and goats are domestic livestock range user in an open access system. All the kinds graze everywhere except sheep which is not accessible to high dunes.

On range feeding a fodder crops and primarily barley is the key problem causing significant grazing pressure by allowing animals to excess many times the natural capacity.

Rainfall, temperature and soil are the key determinants of range improvement sites. This information is normally used by the department of range and forestry.

Range rehabilitation of direct seeding of native shrubs using cultural range improvement practices of pitter and contour seeder is followed.

Reseeding of native adapted species to the improvement site is a key ecological use of Agrometeorogical data. The increase in range forage production have a significant social and economic benefits. Range forage increase will help the livestock subsistence dependent sector of the Bedouin Society.

1.3 The tropical and sub-tropical regions

1.3.1 Australia

Most of the country is characterized by low rainfall and a spatially variable climate, mostly arid and semi-arid although there are some seasonally high rainfall areas in the tropics.

The main ecosystem types are native grasslands, shrub lands, woodlands and tropical savanna woodlands.

Sheep and cattle overwhelmingly dominate Australian grazing. 408 million ha are involved carrying 23 million cattle and 115 million sheep. This pressure is close to the carrying capacity. Soil erosion has accelerated and an increase in native plant communities has occupied significant areas.

Statements on the climate outlook are issued on a monthly basis for 3-month forecast periods. This information can permit an anticipatory adjustment of stocking rates. Data are supplied for pasture growth modeling. Data are available to all sectors of the agricultural community.

National strategies and guidelines for rangeland management have been established which involve collaboration with all stakeholders at a regional level. The Bureau of Meteorology is a member of the policy-formulating committees.

The major direct benefits are the increased efficiency and profitability of agricultural operations. Other benefits include the maintenance of the unique biodiversity of the rangelands, improved water quality and decreasing soil erosion.

1.3.2 Chile

The botanical composition of pastures in Chile is variable, with the following species standing out individually or in combination: Trifolium pratense. T. repens, T. subterraneum, Phalaris tuberosa, Medicago sativa, Lolium perenne, L. multiflorum, Dactylis glomerata, Festuca arundinacea, etc.

Both leguminous and grass species are artificially managed. Natural rangelands are seasonal, depending on the area.

On the basis of known agro-climatic conditions, the above-mentioned species are recommended for areas to which they are adapted used for grazing, hay-making, soiling crops and silage.

Cattle and sheep are predominant in the rangelands. For cattle, systems of continuous, alternate, rotational or strip grazing are used. The animal carrying capacity in Chile varies between 0.2 and 2.0 AU/ha/year. Grazing pressure is different, depending on the forage, and ranges from 10 to 15 ton dm/ha for varieties of ryegrass and from 10 to 11 ton dm/ha (if irrigated) for some leguminous plants. In non-irrigated zones, continuous grazing damages the botanical composition of pastureland and reduces its grazing capacity (small-scale producers).

Agro-meteorological data are not used, except when Experiment Stations recommend specific management on the basis of their research (using rainfall, evaporation and temperature statistics). Agro-climatic aspects are not considered to be very important for livestock activities, contrary to agricultural activities.

Depending on the sector (dairy, meat, etc.), management takes agrometeorological information into account, especially that for short-term meteorological conditions. In particular, agro-meteorological forecasting for periods varying between 24 and 72 hours is used. Generally speaking, most measures aim at improving pastures. The areas used for grazing cattle do not take into account the specific bioclimatic requirements of each species.

There are no figures relating to production. Detailed information can be found in reports on research carried out by universities and research institutes, but was not available when this survey was conducted.

1.3.3 Thailand

Most grazing areas in Thailand are Tropical Natural Pastures and some are improved Tropical Pasture. Pasture production is relatively low in terms of quality and quantity and it fluctuates as a function of seasonal and meteorological conditions.

The rangelands in Thailand are used for local beef cattle, improved breeds of beef cattle, dairy cattle and buffaloes. The carrying capacity is approximately 3 animals/hectare in the rainy season and 1 animal/hectare in the dry season (4 months).

The Department of Livestock Development receives weekly agrometeorological information from the Meteorological Department and circulates this to 33 Animal Nutrition Research Centers. The information is used as guidance to implement activities related to pasture production and to measure and prevent damage due to unfavorable conditions. Measures taken as a consequence include actions to:

- Preserve sufficient roughage for the dry period
- Distribute the preserved feed as a function of agrometeorological conditions and the expected feed status
- Produce pasture seed in the areas that have favourable agrometeorological conditions.

Tropical Pasture Seed Production in Thailand has been successful; in the past sufficient grass and legume seed has been produced, by taking into account appropriate agrometeorological information to predict and use this as one of the most significant production factors.

1.3.4 Philippines

Philippine grasslands or native pastures are generally called “cogonal” from the predominant species “Cogon” (Imperata cylindrica) found in these areas. Other important species are Themeda triandra, Sacchallum spontaneum and Chryspogon Aciculatus. Philippine grasslands constitute a climax vegetation resulting from deforestation and shifting cultivation. These areas are generally rolling to hilly with infertile soils that are generally acidic and low in nitrogen, phosphorus and, in some areas, potassium. There are about 3 M hectares of grasslands in the country. The right to graze these areas is granted through a lease, called the “Forest Land Grazing Lease Agreement (FLGLA)”, issued by the government and supervised by the Department of Environmental and Natural Resources (DENR). In 1971 the area covered under the lease agreements was 1.2 M hectares, but at present only 0.22 M hectare is covered. There has been an encroachment of the grassland areas through other land uses, notably activities related to conversion to cropland, watershed management, indigenous people rights, social forestry, and others.

Rangeland and pastures are commonly grazed by cattle. The general belief is that these pastures can be stocked with one head of cattle per hectare, however, based on various grazing experiments conducted in several bcations of the country, the optimum stocking rate should be 1 animal per 2 to 3 hectares. In general most rangelands are overgrazed, resulting in erosion and the invasion of unpalatable species, which further reduces the carrying capacity.

Rainfall data, more particularly rainfall distribution is the most common agro-meteorological information used in the management of pastures. Researchers, extension technicians and grazers or ranchers are all aware of the information, and therefore pasture improvement and introduction of improved pasture species is generally used to solve the problem of feed shortages in the dry season. Practical examples of the application of rainfall distribution data are: a. the conservation of crop residues and b. the practice (though not general) of ensilage to augment the supply of feed during the dry season.

There are 3 approaches to the improvement of pastures in the country; these are:

- Supplementary seeding of legumes in native pastures, particularly those that are in rolling and hilly areas where cultivation is difficult or not possible
- Use of improved grass/legumes pasture; and
- Intensive grass pasture (use of high yielding species, fertilized under a cut-and-carry system). This is practiced in a few commercial farms.

Among the benefits from the use of agro-meteorological information are:

- the self-esteem that ranchers adopting improved pasture have developed and that results in them becoming good advocates for the improvement of pastures;
- the economically-valid choice of species for improvement, based on agro-meteorological information. Supplementary seeding of legumes increased animal production from 30kg live weight/hectare to 100kg/ha. With improved grass/legume pastures in arable lands a live weight production of 300 to 400 kg/ha/yr has been obtained;
- the access that ecological research technicians have to information, justifying the use of improved pasture, that will prevent erosion and soil degradation in hilly or mountainous areas. Creeping species, like Star grass (Cynodon polystachyum) and lately Humidcola (Brocharia humidicola) are becoming valuable.

1.3.5 Kenya

There are nomadic pastoralists in the northern rangelands and agro-pastoralists and ranchers in the southern rangelands. Their general condition is fair to poor. The harsh climate, especially unreliable rainfall, render these areas only suitable for pasture production, hence the keeping of livestock.

Livestock kept in the rangelands are beef cattle, sheep, goats. Camels are kept mostly in the northern rangelands and only a few in the south. Rotation razing is practiced in the ranches while in open rangelands, the practice is wet and dry season grazing. The carrying capacity ranges from 4-20 ha required per T.L.U. Due to changes of climate and over-grazing the carrying capacity has been declining.

To a limited extent, due to shortage of resources, the agro-meteorological information is passed to the pastoralists through the field officers.

Furthermore, the information will be used to put an early warning system in place. Thus pastoralists can be advised on when to de-stock to avoid destruction of the pastures.

2. Assessment of the desertification of pastureland and meadows in Kazakstan as related to climate change and the possibility of adaptation

Research subject, status of the issue

More than half of Kazakstan (approximately 100 million ha) is desert, and traditionally used for cattle grazing (Fig.1). Wormwood-saltwort and saltwort-wormwood vegetation is predominant on the brown clay soils of the desert plains, where cattle are pastured in the hot season, and occasionally all year round. Shrub and grasses abound on sand and sandy soils, where cattle are grazed in the cold season. Riverbank haymaking is widespread on the marshy riverbank soils of the water meadows in the desert zone. Desert pasture productivity varies from 0.2 to 0.4 t/ha, and riverside haymaking from 1.0 to 2.0 t/ha.

Kazakstan's natural pasture vegetation is greatly harmed by desertification. Of the main natural factors facilitating desertification of desert pasturelands, soil salinization and wind erosion are the most evident. Kazakstan's desert receives more than 6000 MJ/m^2 of solar radiation and a total of 160-300 mm atmospheric precipitation per year and has a mean annual wind speed of 2-3 m/s. In these conditions water loss due to evaporation is several times larger than water input. Consequently, under the influence of soil-climatic factors, the main forms of natural desertification, such as soil salinization and wind erosion, progress in the desert zone. The wind causes sand and light sandy soils to be unstable because plant cover takes several centuries to form. The fairly dynamic intra-zonal soils with riverbank vegetation on the water meadows of desert-rivers are also unstable due to the variable hydrological regime.

The natural desertification processes in Kazakstan have become more prevalent because of economic activities. Human pressure on pastures, in general, is reflected by pastureland degradation and often occurs on water meadows as a result of a decrease in available plant moisture caused by a reduction of water entering the area when river flow is regulated. At the beginning of the 1990s, changes in the soil and plant cover of the desert zone were observed in more than 60 % of Kazakstan. These could be seen as the result of the reduction of natural soil fertility, loss of plant biodiversity and reduced productivity of forage vegetation. In actively farmed areas, soil and plant cover have changed over a very short period of time, i.e. approximately ten years. Moreover, the rate of pasture desertification in Kazakstan could increase this century, as shown by research on climate change in Kazakstan (Pilifosova et al., 1997) and on the impacts of climate change on pastureland at the Kazak Research Institute for Environmental and Climatic Monitoring (KAZNIIMOSK) (Lebed et al., 1997).

Results of research

According to research by climatologists, the air temperature in Kazakstan has increased by 1°C over the last 100 years (Pilifosova et al., 1997). However, due to the doubling of CO_2 concentrations in the atmosphere, air temperatures could increase more significantly over the next 60-70 years and increase by as much as 3-4°C in the desert regions of Kazakstan and even by 5–7°C in some cases (Fig. 1).

Consequently, it is possible that essential changes may take place in the agroclimatic growing conditions of pasture vegetation and in the condition of pastureland in Kazakstan (Lebed et al.,1997). Modeling of the possible changes to desert pastures for the poorer ecological districts, such as the northern Aral region and the southern Balkhash region, gave particularly interesting results (Fig.2). The numerical results are given in Tables 1-3.

The tables show that the condition of pastureland and surface vegetation biomass over the last 100 years could only have changed by 10% if the air temperature increased by 1°C. The relative stability that plants possess could be brought about by feedback reactions developed over a long period of time, providing them with the ability to adapt to (changes in) the external environment. Therefore, it can be suggested that the serious restructuring of desert vegetation ecosystems over the last century was not due to climate change. Short-term seasonal dynamic modeling of surface vegetation biomass (10-15 years) shows that pastureland in Kazakstan is not expected to worsen significantly as a result of an increase of 1-1.5°C in air temperature. However, the expected further 3-4°C increase in air temperature in the desert areas of the Balkhash and Aral regions could fundamentally affect the growing conditions of desert pasture vegetation. In this case, a change in the temperature regime and humidity conditions for plants could be expected, including a minor improvement in the first half of the growing season and a fairly acute deterioration in its second half (Tables 1 and 2).

Surface vegetation biomass modeling confirms the reduction observed, particularly in clay soil pastures (Table 3). Surface biomass could decrease to a greater extent in the desert grasses that have a near-surface root system providing water primarily from atmospheric precipitation. Productivity in shrubby plants on saline clay soils could also decrease considerably. Furthermore climate change could cause increased surface biomass in ephemeral vegetation that has a short spring growing season.

The possible overlapping of the start dates of the growing seasons for spring plants and the summer and winter rest periods were taken into account when calculating the biomass dynamics. The changes in the agroclimatic growing conditions for pasture vegetation associated with possible climate change could cause the fundamental restructuring of the plant cover and its specific content. The expected worsening of heat and water supply conditions for plants in the second part of the growing season and the shortening of their active growing season could negatively affect the varieties sown in the summer-autumn period and the survival of young plants. As a result, this could cause the gradual loss of certain varieties from the plant community and reduce projected vegetation cover in pastures.

In Kazakstan's clay desert soils wormwood plants are likely to be the first to suffer. Vegetation on sandy desert soils could appear less vulnerable to changes in the agroclimatic conditions, because it is able, in general, to actively assimilate even subsoil water, depending on atmospheric precipitation. Therefore only considerable changes in the agroclimatic conditions for these communities could cause individual varieties to suffer, starting with grasses. Furthermore, over the next decades ephemeral plants could abound in plant societies on both sandy and clay soils. Thus, the feed base of the northern deserts of Kazakstan can be expected to be composed of mainly shrubs and ephemerals, the lesser valued feed plants. A negative effect of climate change on the intra-zonal riverbank vegetation may be seen in the reduction of biodiversity and a substantial reduction in productivity.

Research Methods

Climatologists of Kazniimosk studied various scenarios of Kazakstan's climate using USA and Russia climate models developed in the USA and in Russia (Pilifosofa et al., 1997). The agroclimatic conditions of desert lands, the bio-ecological condition of pasture vegetation and its biomass accumulation dynamics were modelled using the pasture productivity model developed by Lebed and Belenkova (1995). The sites for which models were run were represented on a geo-botanical map by separate contours with descriptions of plant communities for clay and sandy desert soils (Fig.2). In places these sites covered 0.1 to 0.3 M ha. The vegetation within these contours was classified from slightly changeable to highly changeable as a result of human factors. In the latter category, the primary plant community is replaced by a secondary plant community. KAZNIIMOSK's archived materials were used, including the results of aero-spectrometric surveys of Kazakstan's pastureland (1976-1993) and agrometeorological field observations. Maps from surface geo-botanical pastureland surveys and multi-year material from desert meteorological stations were also used (1961-1990).

Recommendations for pasture adaptation

Research on the nature of Kazakstan's pastureland shows that it could become more productive under gradual climate change. To ensure this, measures for pasture adaptation need to be taken as from now. The preservation of plant cover, and in some places returning it to its normal rooting condition, requires the implementation of a number of nature conservation methods, shown in Table 4.

Of these methods the first action is the determination of the structure and present condition of plant cover. Vegetation that is at present unchangeable or slightly changeable can than be recommended for pasture rotation, coupled with the reduction of pressure from cattle grazing and haymaking. Pasture rotation is a pastureland utilization system, which envisages the rotation of grazing and rest periods (no grazing) that promote new growth of the pasture vegetation used during the season. Pasture rotation along with the regulation of grazing can be efficiently introduced in enclosed pastures. Plant cover that is, at present, moderately changeable, also requires pasture rotation, reduced pressure from cattle grazing and haymaking and an improvement in pasture surface. If the plant cover structure has undergone particularly serious change due to excessive human pressure and the primary plant community has been replaced by a modified form of plant community or if the pasture has been totally stripped by cattle, then root improvement of the pasture is recommended. This is a process in which the land is ploughed phyto-improving plants are sown. This could be recommended for both present and future climate change conditions.

In this technique, seed plants are chosen from densely vegetated areas depending on soil type and moisture conditions (Table 4). Riverbank ecosystems in the desert zone of Kazakstan are presently under great human pressure due to the sudden reduction in water meadow irrigation following the regulation of rivers via cascading reservoirs. These ecosystems could experience further alteration due to climate change, mainly in the further reduction of water meadows irrigation. In such cases, the optimum water meadow flooding regime needs to be developed in order to maintain the stability of riverbank ecosystems. The system used to release water from the reservoirs onto riverbank farmland on the lower part of the River Chu, proposed by L. Lebed (1980) can be cited as an example. The system is based on a yearly cycle of water release onto the banks in large and small amounts.

Practical use of the results, and development perspectives

Preliminary research showing the possible change of Kazakstan's pasture under the influence of possible climate change was presented at Kazakstan's first national session of the Framework Convention of the UN Convention on Climate Change [5]. Further research into desertification processes in desert pastureland areas can be carried out with sophisticated models of the pasture ecosystems, in which the ??$_2$ content is greater, and by using other climate models, enabling the number of parameters for soil and plant cover condition and climatic and other components of the environment to be increased.

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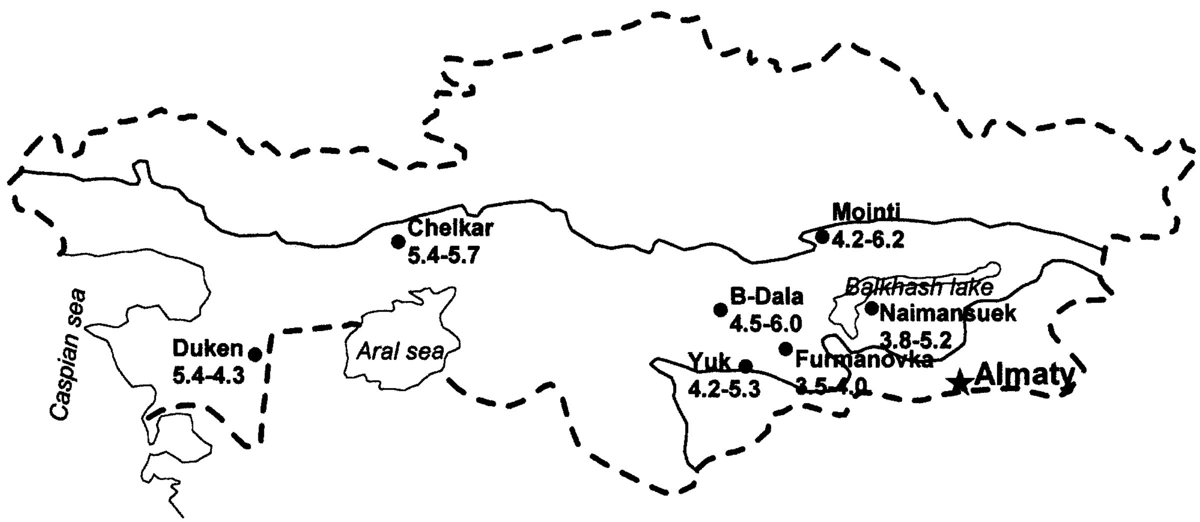

Fig.1. **Possible changes in air temperature (°?) for the desert zone of Kazakstan under the climate change scenarios for 2060-2070 (GFDL-30, climate model, USA).**

6.2 °? - 7.3 °?	- change in average daily air temperature in May and July;
Duken	- meteorological station;
¾ ¾ ¾ ¾ -¾	- northern limit of the desert zone in Kazakstan;
- - - - - - - -	- Kazakstan's border.

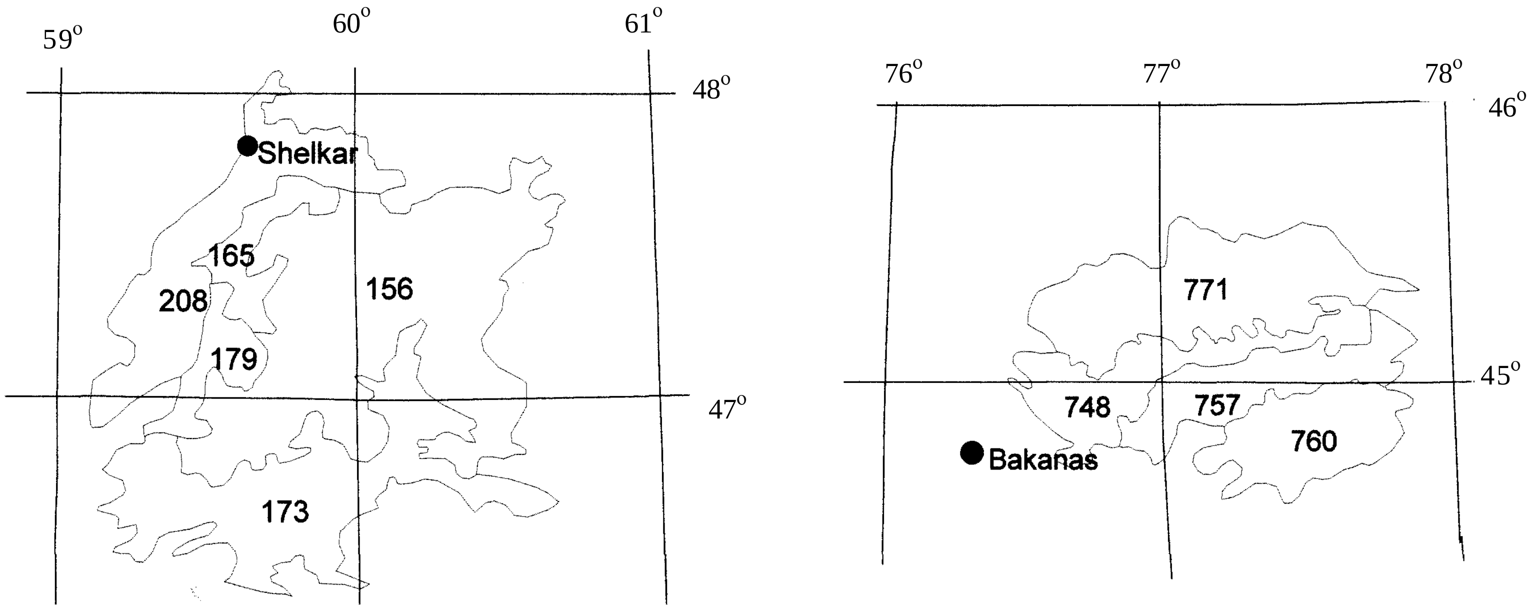

Fig. 2 Research into natural and human-induced pasture desertification in the desert zone of Kazakhstan (excerpts from geo-botanical map. Scale 1: 2 500 000. (KAZGIPROZEM information agency, 1991). Geobotanical classifications with natural vegetation:

156 - Wormwood-saltwort (Artemisia terrae albae, Anabasis salsa, Tulipa bhuseana, Allium decipiens) on grey-brown loamy soils. Slightly changeable

173 - Saltwort-wormwood (Atriplex capa, Anabasis salsa, Artemisia terrae albae) on brown saline loamy, sandy soils. Unchangeable.

179 -

208 - Wormwood-grass (Artemisia terrae albae, Agropirum fragile, Kochia prostrata, Artemisia tomentella) on primitive sandy soils and hillock sands. Highly changeable

748 - Shrubs-wormwood–saltwort (Holoxylon persicum, H.aphyllum, Artemisia terrae albae,Eurotia ceratoides, Kochia prostrata) on hillocky sand ridges and takyr-analagous plains. Sligh tly changeable

757 -

760 - Wormwood-ephemerals with saltwort (Artemisia leucodes, A. Scoparia, Artemisia terrae albae, Ephedra lomatolepis, Kochia prostrata, Eurotia ceratoides) on hillocky sand ridges. Highly changeable

771 - Shrubs-wormwood with saltwort (Eurotia ceratoides , Artemisia terrae albae, Agropirum fragile, Kochia prostrata, Bromus tectorum, Carex physodes, Artemisia leucodes, Ammodendron argenteum, Holoxylon persicum) on hillock sands and hillocky sand ridges. Slightly changeable

● meteorological station

Table 1

Possible climate change in the desert zone of Kazakhstan from instrumental meteorological observations "KAZHYDROMET" , and perspective modeling (Pilifosova et al., 1997)

Natural region (meteorological station)	Climatic Indicators	Climatic Scenario 1 1895-1900	2 1985-1990	3 2010	4 2060-2070
Southern Balkhash region (Naiman-Suek, Zhety-Zhol, Ushtobye)	Air temperature, °C				
	Year	6.0	7.0	-	11.0
	March-April	-	5.0	-	9.0
	May-June	-	19.2	-	23.6
	July-August	-	23.7	-	28.7
	September-October	-	11.9	-	16.7
	Atmospheric precipitation, mm				
	Year	-	211	-	308
	April-October	-	129	-	212
	November-March	-	90	-	96
Northern Aral Region (Chelkar, Ayakkum, Sasaulskaya, Aralsk, Taup)	Air temperature, °C				
	Year	5.8	6.8	8.4	11.9
	March-April	-	2.3	3.5	9.5
	May-June	-	20.7	22.2	25.9
	July-August	-	24.9	26.1	30.8
	September-October	-	11.8	12.6	17.2
	Atmospheric precipitation, mm				
	Year	-	154	166	183
	April-October	-	91	68	123
	November-March	-	63	98	60

1-Instrumental observations; 2-Instrumental observations – basic scenario; 3-G.Gruza and E.Ran'kova's Climatic model (Russia); 4-GFDL-30 climate model (USA)

Table 2

Possible change in agroclimatic conditions of pasture vegetation accounting for the overlapping of calendar date limits for active growth in the desert zone of Kazakstan

Natural Region (Meteorological Station)	Agroclimatic Indicators	Climatic Scenario	March 11-20	March 21-31	April 1-10	April 11-20	April 21-31	May 1-10	May 11-20	May 21-31	June 1-10	June 11-20	June 21-31
Southern Balkhash Region													
(Naiman-Suek, Zhety-Zhol, Ushtobye)	Air temperature (°C)	1985-1990			**7.5**	10.3	12.5	14.7	16.8	18.9	21.0	22.4	23.2
		2060-2070	**4.7**	7.8	10.9	14.1	16.3	18.5	20.7	22.9	25.1	27.2	28
	Humidity Indicator A. Fedoseev, per unit	1985-1990			³ **1.0**	≥1.0	≥1.0	0.93	0.85	0.73	0.61	0.49	
		2060-2070	³ **1.0**	≥1.0	≥1.0	1.0	0.88	0.76	0.62	0.53	0.44	0.37	
Northern Aral Region													
(Chelkar, Ayakkum, Sasaulskaya, Aralsk, Taup)	Air temperature (°C)	1985-1990			**9.3**	12.6	15.4	17.8	19.8	21.6	23.4	24.6	25.7
		2060-2070	**7.2**	12.1	15.8	18.7	21.1	23.2	25.0	26.6	28.5	29.9	31.2
	Humidity Indicator A. Fedoseev, per unit	1985-1990			³ **1.0**	≥1.0	0.72	0.53	0.43	0.34	0.29	0.26	0.23
		2060-2070	³ **1.0**	≥1.0	0.70	0.50	0.38	0.30	0.24	0.20	0.17	0.14	0.13

7.5 - Bold printed figures: Pasture vegetation growth commences

Table 3
Productivity dynamics of pasture vegetation for the different desert regions of Kazakstan, modelled using various climatic scenarios

Vegetation type and map classification no.*	Climatic Scenario	Above-surface biomass (t/ha)						Edible feed (t/ha)		
		March	**April**	May	June	July	August	Spring	Summer	Autumn
Southern Balkhash Region										
Shrubs - wormwood – saltwort, 748	1985-1990	-	0.04	0.21	0.27	0.24	0.24	0.07	0.13	0.23
	2060-2070	0.02	0.09	0.27	0.26	0.24	0.23	0.11	0.13	0.23
Wormwood – ephemerals on sand, 760	1985-1990	-	0.07	0.11	0.09	0.06	0.06	0.05	0.08	0.08
	2060-2070	0.07	0.10	0.11	0.07	0.05	0.04	0.07	0.07	0.06
Shrubs – wormwood with saltwort on hillock sands, 771	1985-1990	-	0.13	0.26	0.94	0.91	1.16	0.12	0.62	0.60
	2060-2070	0.11	0.18	0.52	0.89	0.82	1.09	0.23	0.66	0.70
Northern Aral Region										
Wormwood - saltwort on loamy soils of the hilly plains, 156	1895-1900	-	0.18	0.20	0.39	0.39	0.38	-	-	-
	1985-1990	-	0.03	0.19	0.40	0.37	0.37	0.10	0.19	0.25
	2010	0.03	0.13	0.28	0.41	0.38	0.37	0.12	0.20	0.27
	2060-2070	0.06	0.22	0.27	0.29	0.27	0.20	0.13	0.16	0.20
Saltwort - wormwood on loamy, sandy salinated soils, 173	1895-1900	-	-	0.19	0.71	0.88	0.88	-	-	-
	1985-1990	-	0.04	0.21	0.73	0.70	0.70	0.07	0.07	0.38
	2010	0.02	0.04	0.33	1.06	1.01	1.00	0.11	0.10	0.55
	2060-2070	0.05	0.12	0.52	0.45	0.37	0.34	0.19	0.05	0.26
Wormwood - grass with shrubs on hillock sands, 208	1895-1900	-	-	0.35	0.56	0.58	0.62	-	-	-
	1985-1990	-	0.08	0.40	0.58	0.51	0.50	0.14	0.20	0.31
	2010	0.04	0.09	0.48	0.53	0.47	0.46	0.17	0.20	0.30
	2060-2070	0.08	0.21	0.42	0.41	0.39	0.38	0.18	0.16	0.24

* - For details of the regional geo-botanical maps see Fig. 2.

Table 4

Measures for conserving and renewing natural feed vegetation in the desert zones of Kazakstan in association with progressing desertification influenced by human and natural factors

Category of feed vegetation	Human change to vegetation	Measure relative to climatic scenario	
		1985-1990	2060-2070
Lowland and water meadow used for pasture and haymaking	1. Unchanged	Rotate pasture and haymaking	Rotate pasture, reduce pressure from cattle grazing and haymaking
	2. Slightly changed	*idem*.	*idem*.
	3. Moderately changed	Rotate pasture and haymaking, sow grass	Rotate pasture, reduce pressure from cattle grazing and haymaking sow grass
	4.Considerably changed (second community)	Improve roots: sow grass	Improve roots: sow grass
Pasture on the clay and loam soils of the plains	1. Unchanged	Rotate pasture	Rotate pasture, reduce pressure from cattle grazing
	2. Slightly changed	*idem*.	*idem*.
	3. Moderately changed	Rotate pasture, improve surface: sow phyto-improvers	Rotate pasture, reduce pressure from cattle grazing improve surface: sow phytoimprovers
	4.Considerably changed (second community)	Improve roots: cut furrows and sow wormwood, saltwort and haloxylon	Improve roots: sow swathes of saltwort, haloxylon
Pasture on sand and sandy soils	1. Unchanged	Rotate pasture	Rotate pasture, reduce pressure from cattle grazing
	2. Slightly changed	*idem*.	*idem*.
	3. Moderately changed	Rotate pasture, sow phyto-improvers improve surface: sow phyto-improvers	Rotate pasture, reduce pressure from cattle grazing

Annex 1. Questionnaire on the use agrometeorological information for rangeland and pasture ecology and management

Name:
Country:
Organization:
Address:
Telephone:
Fax:
E-mail: (Office)

1. Does your country have Information about the influence of agrometeorological information on the use and the ecological condition of rangeland and of other areas suitable for grazing by livestock? Yes No

2. Has such information been applied to improve the use of rangelands and pastures? Yes No

If the answer is NO on both these questions, please reply to points 1 and 2 only. If the answer is YES on either of these questions, please reply to all the following points.

3. Describe the kinds of rangeland that are used for grazing by livestock. Give their brief natural characteristics, general condition, and, if appropriate, the changes in agrometeorological conditions that have rendered them more or less suitable for the development and setting-up of pasture production systems.

4. Describe the kinds of livestock that prevail on each type of rangeland or pasture, the grazing systems, and both the charge of livestock and the carrying capacity (the number of animals that can be kept per unit area in a suitable manner), indicating whether the charge is smaller, equal or greater than the carrying capacity and indicate other kinds of man-made impacts on the pastures.

5. Indicate the kind of agrometeorological information that is used for the exploitation of pastures and in the industry of livestock production and indicate to whom the information is transferred. If possible, give practical examples of results of the use of this information.

6. Indicate the measures to improve the pastures and the areas used for the grazing of livestock that are or will be carried out in your country. Describe how agrometeorological information is or will be used for the implementation of these measures.

7. Describe the social, economical, and other benefits that are derived from the use of the agrometeorological information. Please give examples of direct and indirect benefits.

It would be appreciated if you could formulate the answers to these questions in collaboration with the ultimate user community. We will be glad to receive copies of any publications you or your colleagues have written on this or a related subject. You will receive a copy of the report on this questionnaire, together with an acknowledgement of your contribution and that of your collaborators.