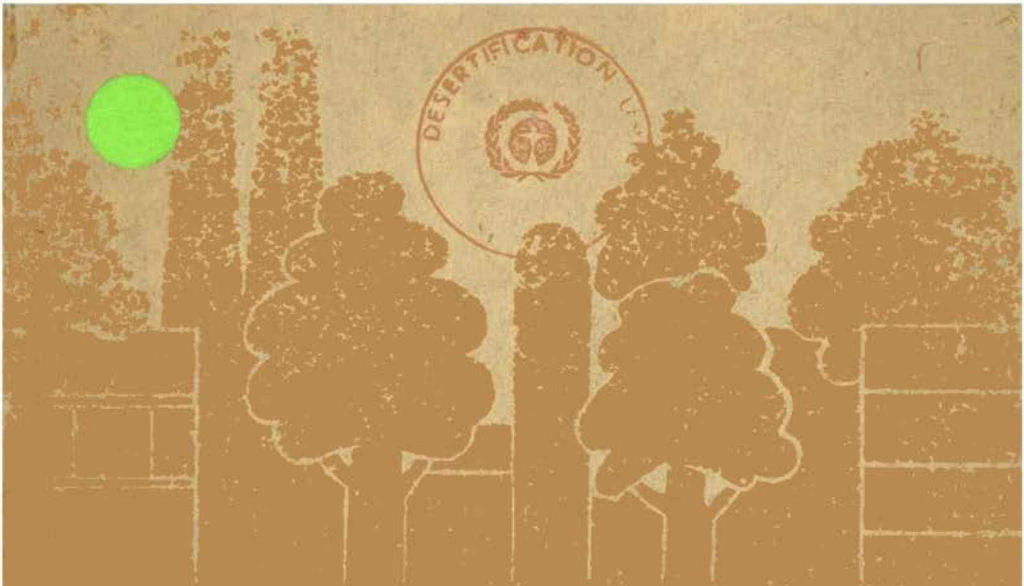

COMBATING DESERTIFICATION THROUGH INTEGRATED DEVELOPMENT

INTERNATIONAL SCIENTIFIC SYMPOSIUM

Tashkent, 1981

ABSTRACTS OF PAPERS

UNITED NATIONS
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Centre of International Projects of GKNT

Institute of Geography, USSR Academy of Sciences

COMBATING DESERTIFICATION THROUGH INTEGRATED DEVELOPMENT

International Symposium

A B S T R A C T S O F P A P E R S

Tashkent - 1981

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INTRODUCTION

This volume includes abstracts of papers presented at the International Scientific Symposium held under the aegis of the UNEP/USSR Project "Combating Desertification through Integrated Development".

While being an integral part of the Project, the Symposium is a logical extension of the training courses on the subject conducted in the Soviet Union during 1980 for specialists from the developing countries of Asia, Africa and Latin America.

The Symposium has the following objectives:

- to assess factors, the spread and methods used to study and combat the process of desertification in the Soviet Union and elsewhere in the world so that the materials presented could be included in the world-wide review of the problem, which, in accordance with the Project Document, is to be prepared in 1982;

- to present information on projects of integrated agro-industrial development, including the urbanization of the desert and semi-desert zone of the Soviet Union; these can be used as illustrative examples, showing the participants of the training workshop the ways of translating into life regional schemes of integrated development;

- to consider and discuss the draft guidelines for drawing up regional schemes of arid lands integrated development.

The above-named objectives were discussed in April, 1981 with the UNEP Executive Director Mr. M.Tolba and were approved.

To achieve the objectives, the Institute of Geography of the USSR Academy of Sciences, an executive body of the Project, joined efforts with the management of the Centre of International Projects of GKNT and enlisted support of the leading Soviet and foreign scientists and specialists known for their work in the field of arid lands development and desertification control. Also, to preserve the continuity of Project activities, former participants of the training courses were invited, since they had had an opportunity to make a critical assessment and generalization of the Soviet experience of combating desertification in the context of the problems peculiar to their respective countries.

These are the concepts on which the present collection of abstracts is based.

Gerasimov I.P., Academician,

Director of the Scientific
Programme of the Project
"Combating Desertification
through Integrated Development"

PLENARY PAPERS OF THE SYMPOSIUM

DESERTIFICATION: FACTORS, SPATIAL DISTRIBUTION, METHODOLOGY OF STUDY AND COMBAT

INTERNATIONAL USSR/UNEP PROJECT "COMBATING DESERTIFICATION THROUGH INTEGRATED DEVELOPMENT" AND ITS IMPLEMENTATION

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At the UN Conference on Desertification, held in 1977 in Nairobi (Kenya), among the many proposals incorporated into the extremely important final document, the Plan of Action, there was a proposal introduced by the Soviet delegation. It addressed the ways of marrying industrialisation and urbanization with the progress of agriculture to boost the development of arid spaces, and their associated possible ecological aftermaths.

The importance attached to the proposal was underscored by the fact that it was set aside into a separate group of proposals to be recommended for national and regional actions.

The proposal's substantiation is by no means accidental - it derives from the well-comprehended extensive experience with integrated development of similar regions in the USSR.

In most developing countries agriculture made a leading contribution to their gross national product whereas the share of industry, construction, transport and the whole infrastructure remained low. Agrarian specialisation was rested largely on semi-subsistent peasant economies based on the fire-clearing system, lagging land-tilling practices and small primitive irrigation "systems". This dismissed all hope of fast economic growth, as even with this substantial capital investments needed to be canalised into building an infrastructure.

After their independence the developing countries proclaimed as their national goal varying degrees of industrial development, proceeding from the level of economic development, political power and balance of class forces.

Accelerated economic development entails certain social shifts closely related to a change of the ecological situation. For the developing countries the environmental problem in its entire diversity is not so relevant or serious as for the developed countries, even though many of them inherited an environment spotted here and there with the "ulcers" of irresponsible, indeed sometimes predatory plunder. Some of the ulcers, influenced by continuing anthropogenic activity, are increasingly showing a hazardous tendency towards expansion in depth and in width. The intensive development of arid and semiarid regions allied with the exploration and production development of large oil and gas bearing provinces or construction unsupported by proper planning and ecological prognostication, gives rise to desertification, degradation of the affected area, increasing pollution, and other adversities.

In the countries prone to desertification the ecological balance is conditional, first and foremost, upon judicious and careful transfer of industrialization and urbanization experiences from developed countries.

The experiences of many countries make it clearly evident that the rise of new socio-economic conditions and social production has fundamentally reshaped the views at the use of nature. This left its mark also on man's inter-relations with the desert: there came a change of attitude from unlimited removal of natural resources with no regard for the future to the rational maintenance of the optimal correlation among the components of this frail ecosystem, with proper assessment and reparation of the damages done to Nature.

On the recommendation of the 1977 UNITAR (United Nations Institute for Training and Research) Conference to deal with alternative economic development strategies for arid and semiarid lands, integrated regional development could present a strategy of desertification control. This is in full agreement with the UNEP general strategy whereby development is invariably associated with environmental protection and improvement. Following this line of reasoning, one comes to the idea about the all-round study of the regional development experiences world-wide, with special reference to the positive and negative role that industrialization and urbanization have to play, under different socio-economic conditions in the ecological state of the environment and the enhancement, prevention or attenuation of desertification processes in the arid and semiarid regions.

The USSR/UNEP Project "Combating Desertification through Integrated Development" was endorsed in 1979. The Project Sponsoring Organization is the GKNT Centre of International Projects and the Institute of Geography, USSR Academy of Sciences, in cooperation with other Soviet organizations as appropriate or other UN agencies concerned, as well as the national organizations nominated by the Project member-states. The Project fulfilment is scheduled for 40 months, from September 1979 through December 1982 and its total cost is 3.1 million roubles (from the Soviet Union's contribution in roubles to the UNEP Fund).

The Project is concerned with identifying and filling gaps in the existing knowledge about the formulation of integrated agro-industrial regional development schemes for territories, concurrent with designing similar schemes for some developing countries. In so doing, it pursues on the one hand, the long-term goals of aiding the developing countries located in the arid, semiard and subhumid regions in control of desertification and protection and improvement of the state of the environment through socio-economic development of the regions on the basis of the integrated agro-industrial approach; on the other hand, its more immediate goals consist of giving assistance to the governments of some developing countries on the formulation of specific development schemes for all or a part of such regions, with a special accent on the types, sweep and socio-economic feasibility of the proposed measures.

The results of the Project Phase I include:

1. Formulation of regional schemes of combating desertification through integrated development;

2. Training national personnel from the member-countries;

3. An international workshop on combating desertification through integrated regional development and preparation of a monograph summarizing desertification control experiences, worldwide;

4. A full-length film about combating desertification through integrated regional development.

SIMILARITIES AND DIFFERENCES IN WORLD'S DESERT ENVIRONMENTS

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The report presents a general overview of climatic conditions, the pattern of desertic lithogenesis, and the flora and fauna of deserts situated in different parts of the world.

Among the deserts reviewed in the report are those of Central Asia, Sahara, Gobi, Atakama and Australia's deserts. Described first is the role of blowout processes, or deflation, in the present geodynamics of the deserts, and their related aeolian relief. Concurrently, note is taken of the traces of old rivers' activity in the contemporary deserts which persist in their topography due to the protective role of desertic crusts (detrital, saline or clayey-takyr).

The desert flora and fauna are characterized with primary attention to the forms of adaptation by new organisms to the severe environment of those territories; the latter are said to be broadly varying in character, depending on the species composition and origin.

Special emphasis is placed in the report on the experience of productive development in the deserts and the processes of increasing anthropogenic desertification in the arid regions.

On all these issues broad and frequent recourses are made to the materials and research data available in the proceedings of the 1977 UN Conference on Desertification, taking place in Nairobi (Kenya).

MAGNITUDE AND CHARACTERISTICS OF DESERTIFICATION OF WORLD'S ARID LANDS

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Desertification is an old as well as a new phenomenon in the arid regions of the world. Three periods in history when desertification has had a particularly acute impact on land resources can be identified: 1) 1,000 to 3,000 years ago when soil erosion and salinization first affected large areas in Europe, Asia, and Africa; 2) 50 to 150 years ago when overgrazing and soil erosion in lands colonized by Europeans left its mark on the landscape, and 3) the last 30 years, when increasing land pressure in developing countries has accelerated all types of desertification.

As the result of past and current land degradation, about 3.3 billion hectares or 80 percent of the world's agricultural land in arid and semi-arid regions is affected by desertification. Approximately 21 percent of the irrigated land, 77 percent of the rainfed cropland, and 82 percent of the rangeland is at least moderately desertified. Africa is the continent having the largest percentage of its grazing and cultivated land desertified, with 86 percent affected. South America, North America, and Asia follow closely behind Africa. Deterioration in the vegetative cover and water and wind erosion are the major desertification processes, world-wide.

Practices for combating desertification are known but the economic benefit of improving deteriorated land is a function of the type of land use and the aridity of the climate. Only about 25 percent of the desertified rangeland is capable of producing economic benefits from reclamation efforts, whereas virtually all of the irrigated land would produce a net positive return from reclamation.

CLIMATIC PERIODICITY AND LANDSCAPE VARIABILITY AS ENVIRONMENTAL FACTORS IN DESERTIFICATION

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Review of environmental factors in desertification indicates that too little attention has been paid to short-and medium-term fluctuations of dryland climates and to topo-edaphic contrasts which determine local thresholds of stability in the natural landscape. Particularly in rain-dependent livelihood systems, drought crises, localized ecological stress through accumulated land-use pressure, or accelerated degradation of critical land units may be decisive. This is apparent in the record and patterns of desertification. Recognition of the significance for desertification of critical climatic periodicity and localized landscape vulnerability can help in formulating combative measures and in designing appropriate management systems.

The claim that the Sahelian and contemporary droughts marked the onset of a more rigorous climatic regime, with expanded dry climatic zones remains unproven. Recognition that rainfall variability comprises fluctuations of varying amplitudes and periodicities is more meaningful for an understanding of the climatic factor in desertification. Drought is the engine of desertification, particularly the longer-term rainfall fluctuations that may exceed the resilience of, or cause imbalance in livelihood systems. The impact of drought depends not only on its climatic severity but also on associated land-use pressures, which may have accumulated in preceding phases of high rainfall. In the foreseeable future rain-dependent livelihood systems in the drylands must adapt to scarce and uncertain rainfall, and agroclimatic indices as a basis for planning should present the probability of the recurrence of drought in terms appropriate to the productive systems at risk.

This concept of the temporal climatic and ecological crisis in desertification is supported in the geographical dimension by evidence from remote sensing, which suggests an initial selective, in-depth pattern of degradation, rather than a broad outward movement of the desert border.

Desertification advances by the aggregation of degraded areas, rather than by expansion of the desert proper. The areas under greatest threat tend to be the semiarid zones.

This pattern of selective desertification advance reveals the importance of localized land-use pressure and the selective response of naturally vulnerable topo-edaphic situations. Since these areas can form centres of widening degradation, their identification is important, and this paper stresses the relevance of the physiographic approach in this context.

At the broadest scale the contrast between mountain-and-basin deserts and shield-and-platform deserts is significant, from the viewpoint of relief, hydrology, soils and landscape stability. Within this broad framework, recognition of distinctive physiographic settings: upland desert, stony desert etc., provides a useful regional framework of reference against which desertification problems and combative programmes can be appreciated, and experience transferred between regions. At a more local scale, the dryland environment fosters and tolerates sharply demarcated environmental units or topo-edaphic settings. Examples are given of the usefulness of mapping such units at scales of 1:250,000 and larger, as a basis for management planning.

DESERTIFICATION IN THE
ARID COUNTRIES

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Since world community realized the danger brought forth by the permanent degradation of the environment in the arid countries, the governments of these countries have made efforts to provide its conservation.

However, not all the countries can tackle this problem successfully. In our opinion, this is attributed to several factors, the first one, being environmental. In the arid countries environment is undoubtedly degraded at present. This situation is worsened by unwise man's activity from one side and animals from the other. Man destroys the environment through forest fires, cutting of shrubs, unsound cultivation practices aimed at maximum foodstuffs production disregarding the rules and laws of environmental development. Animals are no less dangerous as they affect rangelands.

Secondly, there is a social and economic aspect. The abovementioned environmental aspects are in close connection with the socio-economic conditions of the arid countries both in the area of agriculture and pastoralism. Soils of these countries are degraded which results in low crop productivity and, consequently, production of food-stuffs and unsatisfactory sanitary conditions.

The report contains the methodology of elaboration of regional integrated development scheme.

Governments of the countries subject to desertification should "protect themselves" and restore their losses depending on the peculiarities of these countries. To solve this problem it is necessary to adopt a policy of development based on quick reaction and wise assessment of natural resources and the environment.

PRINCIPLES OF DESERTIFICATION DIAGNOSTICS AND ASSESSMENT

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The UN Conference on Desertification (Nairobi, 29 August - 9 September, 1977), after having considered this problem on a global scale concluded that directly or indirectly it affects most countries of the world. Desertification then was defined as "dimunition or destruction of the biological potential of the land that can lead ultimately to desert-like conditions", which applies to tropical, subtropical and moderate arid, semi-arid and sub-humid territories.

Desertification criteria were not defined clearly enough.

The definition adopted by the Conference appears too broad, failing to be operational or diagnostic. It encompasses all the processes of human activity that result in upsetting the biological potential of the land, along with the degradation of the soil and vegetation cover, which may occur in any natural zone. In the absence of clearly defined criteria of desertification it is impossible to diagnose its manifestations with adequate accuracy. Quantitative indices of desertification intensity are not available either. Attempts made to-date towards mapping desertification on a world scale, based on the above definition, have been essentially approximating.

It appears necessary to give a more narrow and specific definition of the desertification process, in clearer scientific terms: desertification is a process of irreversible change of the soil and vegetation cover in an arid area towards further aridization and dimunition of bioproductivity, which, in extreme cases, may result in the area being transformed into a desert. Accordingly, the terms used in this definition should be given a more accurate interpretation:

- irreversible change - a change of the soil or vegetation cover whose rehabilitation to the original condition either requires interference of man or calls for a very long (dozens and hundreds of years) natural process, providing the area ceases to be used altogether;

- arid area - an area, where conditions of tropical, subtropical or warm-to-moderate arid, semi-arid or seasonal sub-humid climate prevail;

- desert - an arid area practically devoid of vegetation cover or senile soil;

- bioproductivity - production of biomass, expressed in t/ha/year;

- soil aridization - change occurring in the soil whereby its capacity to provide available moisture to plants is reduced;

- vegetation cover aridization - xerotization - increase in the number of xerophyllous species at the expense of mesophyllous ones, the overall coverage of the area and bioproductivity being reduced.

On the basis of the above definition diagnostics of the desertification process (establishing its presence) and its assessment consist in the quantifying of the interrelated parameters of the extent of soil and vegetation aridization and of bioproductivity. Like any other process, desertification can be diagnosed and assessed only by comparing the condition of a given area at different moments of time, or by comparing two different areas simultaneously. The rate of the desertification process can only be determined in the former case, whereas the latter case establishes the fact that the process is going on and its intensity.

The definition includes both the natural and man-induced processes of desertification. The parameters of soil cover degradation, such as erosion, salinization, alkalinization are not specific for desertification, and therefore cannot be used in its diagnostics or assessment.

RISING ENERGY COSTS: A NEW AND
POTENTIALLY SERIOUS DESERTIFICATION
FORCE IN THE UNITED STATES

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Due to rising fossil fuel and electricity costs, energy has become a significant variable in the economics of irrigated agriculture, particularly irrigated agriculture that depends on pumped groundwater. In the Pecos River Basin (southwest Texas), farmers have had to abandon some 190,00 acres of cultivated (primarily cotton) land as a direct result of higher energy costs. To the north, on the Llano Estacado, groundwater pumping now costs about $60 per acre-foot, compared with $1.50 per acre-foot ten years ago. In the Santa Cruz and Gila River Basins (central Arizona), farmers have begun to abandon once irrigated fields to the ravages of the wind and weeds because higher energy costs have made their cultivation uneconomic.

A second major direct effect of rising fossil fuel costs has been increased demand for wood, an alternative fuel. There has been a surge of wood gathering and cutting on the arid commons, managed by the U.S. Forest Service or the Bureau of Land Management. Increasing sales of wood stoves and high private market prices for wood ($65 to $120 a cord) suggest further expoitation of trees on the arid commons in the near future. Heretofore, wood gathering has not been a major desertification force in the United States, except in specific places such as the Navajo Indian Reservation.

The indirect effects of rising energy costs are harder to quantify but are no less real. Perhaps the most powerful indirect effect is that rising energy costs make urban areas in warm climates (arid or nonarid) more economical than those in cold climates (arid or nonarid) in terms of their living and light industry costs. Hence, they contribute to their growth. And as the urban areas in arid warm areas grow, they must reach out further and further for water to sustain that growth. The Los Angeles Metropolitan Area is probably the classic case of this phenomenon. The result - increasing desertification beyond the environs of the arid land city.

The developments suggest that energy considerations should be an essential ingredient in any integrated effort to combat desertification. Especially crucial is the utilization of indigenous solar and wind resources. A variety of technological options appear to be available today or in the threshold of availability - photovoltaic cells for powering pumps, wind-driven turbines, solar salt ponds, etc. Of equal importance is the utilization of water-conserving technologies, e.g., low-pressure irrigation systems, water recycling processes, solar-powered desalinization, etc.

Water self-sufficiency will become increasingly vital for arid areas because as energy costs climb so will the cost of transporting water, i.e., interbasin transfers. So, too, will the cost of draining saline irrigation water out of basins such as the San Joaquin in California.

ENVIRONMENTAL PROBLEMS AND DEVELOPMENT IN ARID LANDS; REFLECTIONS ON A MAN AND THE BIOSPHERE PROJECT

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For the past two years the Arid Lands Information Center within the Office of Arid Lands Studies, at the University of Arizona has been compiling handbooks on natural resource development and environmental problems in a number of developing countries, mainly in arid regions of the world. This project is sponsored jointly by the U.S. Committee of the U.N. Man and the Biosphere Programme (MAB) and the U.S. Agency for International Development (U.S. AID). The project represents the first stages of an attempt by U.S. AID to integrate an environmental awareness into development planning.

A substantial proportion of development projects have had, and continue having adverse effects upon the environment, and U.S. AID projects are certainly no exception. It represents a major advance in the field of development activity that within the last decade such difficulties finally have been recognized, and steps are being taken to rectify them.

The handbooks, or more accurately "environmental profiles", are envisioned as the first part of a more thorough analysis of resources and resource management, environmental problems, and the interrelation of these factors with development planning. To-date environmental profiles on more than a dozen countries in the arid regions of Africa, the Middle East and South Asia have been compiled. Natural resources of each country, particularly mineral, water, soils, vegetation, and wildlife have been examined. Each of these resources is surveyed, but more importantly, the management and use of the resources is reviewed. Specific current and potential problems are identified to show which areas are or may become most critical in terms of environmental degradation. Discussion of the major environmental problems includes not only the physical aspects, but also socio-economic or institutional factors behind environmental degradation.

Most physical aspects of environmental problems have been covered in great detail in recent research on and discussion of desertification. The common factors present in every country profiled in the MAB project include degradation of natural vegetation cover, severe soil erosion, and a number of environment-related health problems. In most arid areas, expansion of agriculture depends upon irrigation projects, and such projects are leading to increasing soil and water salinity. Countries dependent upon irrigation from great rivers, such as the Nile and Indus, also have to contend with waterlogging of productive soils. Overpumping of the groundwater aquifers is resulting in declining water tables, and seawater intrusion in coastal areas.

By contrast, the socio-economic and institutional factors behind these problems have received much less attention than the physical apsects. While it may be noted that overgrazing or clearing for agriculture are two of the major factors in depletion of vegetative cover and thus factors in soil erosion, the tendency has been simply to blame the ingorance of the farmer or herdsman for the problem. However, farmers and herdsmen are quite often perfectly well aware of the detrimental effects of many of their actions. Traditional land use systems are usually well adapted for causing a minimum of damage to fragile ecosystems. Very often the intrusion of modern factors disrupts traditional systems, leaving the inhabitants with the choice between starvation and actions which will cause degradation of the environment.

Making these choices often involves institutions at national level in most countries, to the extent that environmental degradation is, in a sense, actually planned in many cases. It is well known, for instance, that massive irrigation projects may well lead to soil salinization and water-logging, depletion of groundwater resources, or increased incidence of certain diseases. However, the alternative of not initiating such projects and thereby courting massive food shortages is not viable.

Such perspectives may not be readily apparent from the analysis of the situation in individual countries. The trend becomes strikingly clear, however, then it is seen in nearly every country profiled. The physical problems of environmental degradation are well known and well researched. From a purely technical point of view nearly all can be solved. The major focus, however, must shift away from action exclusively on this level. Causes of every environmental problem have socio-economic and institutional aspects which must be addressed if there is to be any hope of lasting solutions.

EXPERIENCE OF SEDENTARIZATION IN THE ARID LANDS OF THE USSR

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Nomadism as an economic and cultural way of living adhered to by nomadic and semi-nomadic peoples of the world's arid zones emerged in pre-historic times. In some countries of Asia and Africa it still continues to exist.

A study of the historic experience in eliminating nomadism in the USSR represents not only scientific and practical interest, but is a factor of international significance, since elimination of nomadism constitutes a very important problem for many developing countries of Asia and Africa. Theories are being propounded abroad calling for a come-back to the nomadic way of life, which allegedly will be conducive to preserving a better natural balance in arid territories. This theory does not rest on any scientific fact, while it demonstrates the old colonial principle of barring the inhabitants of deserts, semi-deserts and dry steppe areas from technological and social progress.

The victory of the October Revolution in the Soviet Union created a decisive condition for massive elimination of the nomadic way of life among the Soviet Union's nomadic peoples (particularly in Soviet Central Asia and Kazakhstan). The problem of eliminating the age-long socio-economic and cultural backwardness, illiteracy and ignorance among the population of what used to be Russia's colonial backyards, including nomads, was one of the priority challenges of the Soviet Administration in its very early years. In the Republics of Soviet Central Asia and Kazakhstan special attention was given to particularly backward life patterns among nomadic livestock breeders. The Soviet Government took a number of important economic and political steps to settle the nomads. A lot of institutional, economic, educational and preparatory work among the nomadic peoples accompanied the transition.

One of the main factors that contributed to the settlement of nomadic livestock breeders was collectivization of individually owned livestock breeding units. Massive settlements of nomads and semi-nomads of Central Asia and Kazakhstan coincided in time with the period of creating livestock breeding collective and state farms and was predominantly completed in 1936.

The settlement of nomads proceeded on the basis of replacement of traditional nomadic economy with range breeding. The settlement of former nomads in Soviet Central Asia and Kazakhstan against the background of developing socialized economy proved to be an important factor conducive of progressive changes in the work patterns of animal breeders, in their traditional living patterns and culture.

POPULATION OF THE WORLD'S ARID AND SEMI-ARID LANDS

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1. Studies of the population problems of arid lands prove the importance of subdividing these into arid and semi-arid. Population density for the former normally does not exceed 0.1 man/ km^2, in the latter case it frequently goes up to 5-10 man/km^2. Even today arid lands feature nomadic and semi-nomadic cattle husbandry, a settled way of life being a characteristic of oases only, no matter natural or man-made (e.g. near mining centres). Semi-arid lands display prevalence of settled life, with possibilities for dry farming development, where semi-nomadic cattle husbandry is usually of secondary importance. Towns are more common here, their functions not necessarily limited to the servicing of nomads or semi-nomads.

2. Apart from the differences arising from the extent of aridity, very important are the differences between the habitats with indigenous population practicing traditional forms of economic activities (in which sometimes modern mining centres are vital components without destroying the "background" as a whole) and the habitats whose population has formed only recently, and

now equipped with sophisticated technology operates modern large-scale projects. The former type of habitat is represented, for example, on the Arabian Peninsula, the latter - in the deserts of the United States or Australia (where even now one can find the traditional backward economy of the few aboriginals). Highly mechanized economy of the habitats of the second type explains why they are so sparsely populated. It is the habitats of the first type that will be dealt with mainly in this paper.

3. In the socialist countries, transformation of traditional economy has resulted in the replacement of nomadic way of life by pasture animal husbandry. Irrigated areas are expanding, and modern technology is being introduced everywhere. All this has sharply increased development capacity and economic potential of arid and semi-arid lands, at the same time cutting down these areas by building large irrigation schemes.

4. To assess the importance of population related problems of arid and semi-arid lands globally demographic parameters of population are essential. These areas make up 20 and 15% of inhabited dryland, accommodating roughly 650 mln people, i.e. nearly 15% of the world population, 100 mln people living in the arid lands. In Asia (without USSR) live as many as 400 mln people, and in Africa - over 200 mln (roughly 45% of the continent's total population).

5. The population of the lands under study can be subdivided into "town", "settled rural", "semi-settled", "semi-nomadic" and "nomadic". Correlation between these groups is subject to constant change, and has been particularly in the postwar period. Thus, percentage of town population rose from 15 to 35% during 1950-1980. At the same time, the number of nomads and semi-nomads

reduced by half with the result that now they constitute less than 1/10th of the total population of the arid and semi-arid zones (over 90% of nomadic people are concentrated in the arid zone). It is only in Sahara and the Arabian Deserts that the number of nomads and semi-nomads exceeds 1/4th of the total population.

6. Of the total number of nomads and semi-nomads of 65 mln, around half live in Africa, and just under 30 mln - in Asia outside the Soviet Union. Most nomads and semi-nomads currently live in Pakistan, Saudi Arabia and China (5 mln each), the Sudan (4 mln), Ethiopia (3.5 mln), Iran, Afghanistan and Somalia (3 mln each), Nigeria and Algeria (2 mln each), Morocco and Turkey (over 1 mln each) etc.

7. Population of the lands under study has a comparatively high birthrate (2-2.5% p.a.), the annual variations being much higher than anywhere else in the world. These variations are due to the rapidly changing ecological situation. For example, the Sahelian drought which lasted for years provoked a dramatic increase of deathrate and a reduction of birthrate, the natural population growth declining more than by half compared with annual averages of the postwar period. No significant differences can be observed in migration patterns of rural population and of the people who settled in towns or are engaged in mining industry. A stereotype demographic behaviour proves to be rather persistent here. However, it should be stressed that natural population growth figures for nomads and semi-nomads are at least by 1/3rd lower compared with settled population.

Negative balance of migrations has a noticeable effect on the dynamics of population strength in some habitats of arid and semi-arid lands, whereby population moves from arid to semi-arid zones, and on to adjoining areas with adequate water supply, coastal towns etc.

8. Ethnogenesis of the peoples inhabiting arid lands took place at the time of prevalence of a specific economic/cultural type of population known in the Soviet science as "nomadic cattle breeders of steppes and deserts". The intrinsic features of this type are: concentration of material means of existence in cattle (of different species); extremely low productivity of rangelands used for cattle stocking; high mobility of the people following the herds; availability of animals for transportation purposes (horses or camels), making it possible to keep together with the herds; portable dwellings; dominance of livestock products (milk, meat) in the food ration, and a number of other ethnographic traits.

9. It appears as if the number of a particular people at earlier stages of their ethnic development is determined by the productivity of natural rangelands (by the number of livestock). Considering the high mobility of the population, a loss of this productivity contributed to mass migrations, including military invasions. But even without such resettlement raids, now a thing of the distant past, the high "current" mobility of the population encourages the formation of large, "expanded" over considerable areas, ethnic communities, or meta-ethnic communities, made up of closely-related peoples (e.g. Arab community), characterized by similarities in historical development, frequently by understanding the other's language, by uniformity of the life-style, religion etc.

On the other hand, the low level of productive forces development typical of the economic/cultural type of nomadic cattle breeders of arid lands restrained the social development of the peoples belonging to this type in that it conserved such obsolete forms of social structure as tribalism (at present, survivals of a kin-tribe division of the people practically occur only among nomads and semi-nomads) or some traits of feudal relations; this imprint of social backwardness is particularly striking where people practicing traditional nomadic or semi-nomadic economy find themselves in close neighbourhood with modern industrial centres.

10. The key question that straddges all studies of arid land population lies in the transformation of a nomadic lifestyle into a settled one (preceded by linking nomads with settled population) and in the territorial organization of resettlement in its future forms, essentially those of rational settlement.

It should be pointed out that even when the nomadic lifestyle was dominant, centres of human settlement were a social necessity, at least since the beginning of commodity-market relations in the life of nomadic people. Stationary points for the exchange of livestock products to goods, manufactured by artisans or brought in by tradesmen from outside the arid-nomadic habitats became a necessity a very long time ago. This was combined with the role of "towns in the desert" as administrative, religious and military centres.

Today, the focal points of human settlement - "towns of the desert" as well as towns surrounding the deserts, some of them hundreds and even thousands of years old, occasionally get a status of worldwide political, religious and even economic centres. They also become important transport route junctions (mostly motor roads that have come to replace caravan paths).

The social need of nomadic communities for such bases is growing. Arid habitats are surrounded by towns, whose various links with nomadic world continue to be an important function among other things. Also, the towns are developing inside the arid habitats proper. Nomadic communities increasingly adapt their life-style by way of linking it with contagious towns as centre of human settlement.

11. From the medico-geographical standpoint, arid lands do not favour settlement. Even the indigenous population, although "genetically adapted" suffer a good deal of inconveniences (lack of water resources, sandstorms, monotony of landscape etc.). For the new settlers, adaptation to conditions of high aridity is all the more burdensome. It is for this reason that they (and eventually the indigenous population as well) welcome enthusiastically all kinds of technological gadgets, neutralizing (or minimizing) the adverse effects (air-conditioning of rooms, forced water supply, planting trees etc.). As deserts give way to semi-arid conditions, the situation considerably improves medico-geographically, but this notwithstanding, the "technology of overcoming the aridity" still remains important.

12. Arid lands constitute one of the essential reserves at the disposal of mankind for settlement and development of economic activity. Methodologically it would be wrong to try and set any limits to the development capacity of these lands for the future: this capacity at any historic moment (and for each individual habitat) will be determined by the level of productive forces development and their nature, this level being inseparable from the resource potential, both originally present in the environment and man-made.

DEVELOPMENT OF SMALL AND MIDDLE-SIZED SETTLEMENTS AS A MEASURE TO COMBAT DESERTIFICATION

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In combating desertification the development of small and middle-sized towns is of paramount importance. As nuclei of integrated development distributed throughout drylands, they would take over important functions of catering for a surrounding area. In the vast expanses of drylands where distances are usually great and infrastructure poor only a decentralized approach to the desertification and development problem will have the necessary effect. Better living conditions can only be achieved by a broader dissemination of extension services.

Functions of these settlements should be:

- Improvement of roads and means of transport.
- Improvement of animal marketing.
- Processing of animal products.
- Provision of veterinary and medical services.
- Improvement of water supplies.
- Establishment of labour-intensive industries.
- Land use control and testing of new land use systems.
- Research and training.
- Organization of enlightenment campaigns.

A standing council of local experts would be advisable for combating desertification in their specific area with its specific kind of environmental problems.

IMPORTANCE OF AGRICULTURAL MECHANIZATION IN PREVENTION OF DESERTIFICATION AND RECLAMATION OF DESERTIFICATED SOILS

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Soil is the principal element of agricultural and industrial development of a nation. Soils where nations live and rule should be rationally used.

Danger of erosion and desertification confronted throughout the world can be lessened by implementing advanced farming techniques. Desertificated areas can be reclaimed into arable lands by use of rational and improved farming techniques.

Factors leading to mobilization of soil particles and thereby desertification can be grouped as natural and human.

1 - NATURAL FACTORS

1.1 Climate

1.2 Soil

1.3 Vegetation

2 - HUMAN FACTORS

2.1 Improper farming pattern and crop rotation

2.2 Improper uses of land

2.3 Improper use of machinery and equipment

2.4 Over-grazing

2.5 Use of manure and grasses as fuel etc.

1.1 Climate:

Biological, chemical and physical factors affecting soil formation are closely related to climatic conditions, e.g. precipitation, heat, moisture, wind.

1.2 Soil:

Crust formation on the surface, which is related to soil texture, plays a great role in severity of erosion and desertification.

1.3 Vegetation:

The degree of erosion is dependent on factors such as the kind, height and density of vegetation, the system of rotation and the distribution of vegetation. The denser is the vegetation the lesser is erosion.

2 - HUMAN FACTORS:

Erosion is also attributable to human factors as well as natural factors such as soil and vegetation.

2.1 Improper farming systems and rotation:

Improper farming systems applied without taking into consideration the relationship between soil, climate and vegetation results in degenerated soil structure and reduced soil fertility and water holding capacity.

2.2 Misuse of lands:

Lands are grouped taking into consideration the type of use, and they should be used in line with their characteristics. Land misuse causes desertification.

2.3 Improper use of machinery and equipment:

In order to ensure increased agricultural production, the suitability of the machinery and equipment to the soil structure and their effect on swelling the soil and on expanding the projection surface of the land should be tested. Improper use of machinery increases erosion and desertification. Therefore, due importance should be given to an appropriate and planned agricultural mechanization for preventing desertification or rendering the desertificated lands suitable to agriculture.

2.4 Over-grazing:

Each pasture has a capacity to feed a given number of livestock. Overusing and overgrazing damage the flora covering the soil surface of the pasture subsequently stimulating the desertification.

ECONOMICS OF GUAYULE RUBBER

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Guayule (parthenium argentatum gray) occurs naturally in certain desert regions in the Americas and in Central Asia. For almost 50 years during the first half of this century a small but important guayule rubber industry operated in Northern Mexico. Today, several nations with semi-arid regions are considering the possibility of once again producing natural rubber from guayule.

This paper examines the economics of guayule rubber production. The paper focuses primarily on the economics of production in Northern Mexico, where plans to reactivate a guayule rubber industry are, at the present time, furthest advanced.

WORLD PRACTICE OF ARID LAND DEVELOPMENT AND COMBAT OF DESERTIFICATION (THE SOVIET UNION)

DEVELOPMENT OF PRODUCTIVE FORCES IN THE ARID ZONE OF THE USSR

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World's arid lands account for nearly 30% of the dryland, and, combined with areas where droughts occur 10-15 times and more per 100 years - for 50-60%. Arid lands are huge expanses of land on all continents, e pecially in Australia, Africa, Asia, The arid zone includes the cotton and rice belts as well as the areas where other south crops are cultivated. Besides, the zone serves as a habitat for 1-1.5 bln cattle and other domestic animals.

Despite being situated within northern latitudes, the USSR has a sizable area of arid lands. Apart from the areas where severe droughts are rare (the south of the Ukrainian Union Republic, Middle and Lower Volga, the Northern Caucasus), there are areas where permanent aridity and scorching droughts constitute a climatic feature, being a typical phenomenon. These are deserts and semi-deserts, occupying 14% of the USSR territory. In some Republics, desert-covered areas are considerable: from 10% and more - Azerbaijan, Kazakhstan, Tajikistan; up to 50-80% - the Uzbek and Turkmen Union Republics.

Deserts and semi-deserts of the USSR are endowed with various natural resources: fuel-energy (oil, gas, bituminous coal, solar and wind energy, ferrous, non-ferrous and rare-earth metal ores, chemical raw materials (phosphate rocks, sulphur, potassium and table salt, iodine-bromine waters etc.) for construction industry; agro-climatic potentials (long vegetation and frost-free periods, solar insolation); medico-climatic resources; fresh groundwater; vast area of potentially fertile grey soils (if irrigated); rangelands suitable for sheep stocking all year round.

The population of the USSR arid lands is well adapted to the local natural conditions and have been practicing irrigated and dry farming, sheep and camel breeding for centuries.

Thanks to the October Revolution, the once backward outlying areas of the Russian Empire have become sovereign socialist republics with advanced agriculture and industry.

Industrial growth gave rise to urbanization. In the oases, side by side with ancient towns, some large kishlaks were transformed into cities. In the desert proper, the few existing towns function as local economic and administrative centres, with many townships emerging around mines.

During the years of Soviet power, major problems of economic development of the USSR arid zone republics have been resolved: (a) fuel-energy problem - by building high-capacity hydroelectric power plants in the mountains and on the rivers in the plains as well as gas-turbine stations, all making up a unified power grid linked with the USSR power system; (b) irrigated farming - by reconstructing the old irrigation network and building a new one, comprising long main canals of large carrying capacity, water reservoirs; by regulating the flow of the Amu- and Syr-Darya Rivers; by effecting inter-basin water transfer schemes to improve water supply conditions in water-deficient areas; by expanding on this basis the old oases and setting up new ones where there used to be desert barren land; (c) animal husbandry - by introducing seasonal pasturing to replace nomadic cattle-breeding, bringing water to the rangelands by modern technological means (water pumping, construction of waterworks etc.), stockpiling insurent fodder reserves.

The solution of these problems is closely related to the desert land development based on the achievements of science and technology, using experience of the past with proper backstopping. Desert development is usually understood as utilization of its resources. In the USSR, the use of natural resources also includes rehabilitation of the desert resource potential. Natural resources management is scientifically-based, because science has become a society's productive force. Not only are the natural resources being studied, but subject to investigation are also regularities of their formation and distribution, peculiarities of a particular area, with measures to restore the natural environment being planned well in advance. Efforts to delay the processes of desertification are considered long before the risk becomes a reality. Envisaged are measures to reduce the negative effects of desert development - disturbances of ecosystems, quantitative and qualitative correlation of their components. Desertification takes place both due to natural processes and human activity. The damage being inflicted to nature and economy is neutralized or repaired through the various environment protection measures as well as by special provisions (financial or technological) made in the desert resource development industrial and town planning projects aimed at timely prevention or elimination of the adverse effects of natural resources utilization.

Scientific research into the laws governing the desert evolution, the processes and aftermath of desertification is carried out by making route and site surveys, aerial photography, lab experiments, setting up temporary and stationary research centres, by visual methods and by evolving natural models.

AGRICULTURAL LAND USE IN THE ARID AREAS OF AZERBAIJAN

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Arid areas in the Republic occupy 5.2 million hectares or 60% of the territory. This area is populated by more than 4.5 million people, or more than 75% of the Republic's population. The population density in the arid regions stands at 86 pers./km^2.

Arid areas are represented basically by semi-desert and dry steppe landscapes with a relatively small (as compared to Soviet Central Asia) disproportion between heat and moisture. The natural conditions in the arid regions of the Republic as well as deserts of Soviet Central Asia can be conducive to irrigated agriculture and livestock breeding. Apart from that the subsoil of arid areas holds deposits of oil, gas, construction materials etc., that can be used industrially. In the years of Soviet Administration the Republic has launched a number of programs to prevent desertification and to promote irrigated agriculture. The old irrigation system has been fully restored, a new one has been built with the total canals length of more than 500 thousand km, 32 water reservoirs have been created of which the two largest are Mingechaur and Agstafa. Out of the entire agricultural produce harvested in the arid zone more than 80% are accounted for by irrigated tracts. In the years of Soviet Administration the area of irrigated land has doubled. The predominant option of the arid zone occurs in the large Kura-Araks lowland, whose area is 2.7 million hectares or 31.7% of the Republic's territory, and populated by 1.5 million people. It gets 2,000-2,200 hours if sunshine per year, one of the country's highest. This amount of heat is sufficient to grow southern heat-loving cultures. However, moisturization patterns, especially the hot summer with little precipitation (250-300 mm) make it necessary to regard the Kura-Araks lowland as an area in need of large-scale reclamation programs that might intensify agricultural production.

A sizable portion of the Kura-Araks lowland is a classical water-logged, high salinity area, especially on irrigated tracts. Solonchaks and secondary salinization tracts make it necessary for the government to allocate considerable funds to control salinity on irrigated lands.

The traditional pattern characterizing arid regions and combining two basically different types of agricultural economy - intensive land-tilling based upon irrigation and extensive livestock breeding relying upon natural forage is being gradually improved. As irrigation progresses, arid areas lose their oasis nature, large rangeland areas become cultivated, which creates conditions for intensive livestock breeding. In the 11th five-year period plans are made to reclaim about 70,000 ha of Azerbaijan's irrigated lands.

INTEGRATED DEVELOPMENT OF DESERT AND SEMI-DESERT LANDS IN CENTRAL ASIA

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The country-wide programme of agricultural development now underway in the USSR is directed towards the achievement through consistent approach and action of the national goals concerned with full supply of the people's needs for agricultural products. In this respect, land irrigation and reclamation constitutes an essential factor in the effective management of major economic and social problems.

The latter's role is nowhere so great as in Central Asia with over 90% of its area occupied by vast desert and semidesert spaces like e.g. the Hunger, Karshi, Dzhizak and Farish steppes which possess yet-untapped potential for the development of irrigated agriculture.

The natural and economic conditions of Central Asia, the ever growing demand for agricultural products, cotton among them, and the increased economic capabilities of the state underlie the plans for irrigation and development of large desert land areas with a view to the creation of new economic regions there. The plans envisage sizable investments in the construction of not only technologically perfect irrigation systems, but also the facilities to accommodate the needs of agriculture, including housing and appropriate cultural and welfare facilities, repair depots, warehouses for agricultural production units, road construction and installation of various engineering supply lines to bring water, electric power, gas, heat, and other resources.

With the solution of such a complex problem in mind, the Ministry of Reclamation and Water Management, USSR, established a special organization, the Chief Central Asian Authority for Irrigation and Construction of State Farms (Glavsredazirsovkhozstroi) provided with a high-powered supporting construction and building materials industry and responsible for the design, construction and temporary operation of irrigation systems and newly-built state farms.

This method of construction and land development, appropriately termed "integrated", was pioneered in this country in the Hunger steppe and has since been successfully followed in semi-desert land development projects in the Karshi and Dzhizak steppes and other lands areas.

With the basically new forms of construction and land development management, it has been possible to solve the problem of raising rapidly the material well-being of labourers in former desert areas. On the whole, irrigation promotes accelerated development of productive forces in the region being developed. Based on the produced agricultural output, tens of production units are brought into operation in the cotton-processing, light and food industries.

Execution of measures towards improved environment is vastly important for provision of healthy climate and better landscape and ultimately for keeping in permanent residence on new lands of the pioneer developers arriving here from well-settled regions.

Irrigation of desert lands in the arid zone by the integrated method triggers off profound changes in the socio-economic basics of human life and makes possible sustained good yields of agricultural crops in unfavourable natural and economic conditions.

ANTHROPOGENIC PROCESSES OF DESERTIFICATION IN CENTRAL ASIA

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Violation of the ecological balance in arid environments triggers development of desertification.

Desertification can result from environmental (natural) and anthropogenic causes as well as from their combinations. Natural desertification is attributed to aridization of the area and advancing salinization of soils and ground waters. Anthropogenic desertification is a result of unwise man's activity.

Causes of desertification both natural and anthropogenic are complicated, variable in different regions and closely associated. Their intensity determines the duration, dimensions and degree of desertification. Vulnerability of the area to desertification and the effect of its impact are defined by the climatic factors (aridity, rainfall supply and its seasonal distribution pattern etc.), soil structure and texture, terrain topography, species composition of vegetation as well as the density of human and livestock population, the type, intensity and degree of mechanization of economy.

Man's economic activity has strong and multi-aspect impact on vegetation of desert rangelands. The latter includes overgrazing resulting from the excessive pressure on rangelands; partial or complete deforestation due to cuttings of trees and shrubs, during engineering and construction, road-building, irrigation and reclamation works.

Cattle grazing can lead to change in top-soil properties, plant species diversity and quantity pattern, age groups of population dominants, structure and number of associations and microassociations, phytomass production values, while within sandy areas also topography, groundwater table, microclimate etc.

Cutting of shrubs, especially a complete one results in their total destruction which can be regarded as a first step towards desertification. Deforestation triggers severe wind erosion processes and extension of sand dune areas adjacent to oases, watering wells and settlements.

Intensive development of desert resources for the needs of expanding industry, new settlements and road-building causes a number of adverse effects on desert ecosystems.

Processes of desertification are typical not only of the rangeland zone but also of the zone of irrigated farming. Here one faces the need to cope with the problems of waterlogging, secondary salinization of soils and also the removal of the increasing amount of drainage waters outside the oases.

Irrigation development and river flow regulation have caused significant environmental changes within the catchments of Syr-Darya, Amu-Darya and Ili rivers. The ecological consequences of irrigation development and river flow regulation include the drying of the Aral Sea, desertification in the deltas and floodplains of Amu-Darya and Syr-Darya, severe soil salinization, decrease in the rangeland productivity.

NOMADIC PASTORALISM AND PRESENT RANGELAND USE OF KARAKUM DESERT

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For a long time the territory of what now is Turkmenistan has been the site of extensive nomadic sheep and camel breeding. Before the October Revolution of 1917 they used to breed Karakul and fat-tail sheep, rough fleece goats and dromaderies.

The way in which rangeland was used was a factor of available water. Groundwater was used to supply water to the rangelands as was the surface run-off from natural precipitation on takyrs. Water wells were used as watering points, or primitive open kuym and karak water reservoirs. The high salinity of groundwater of the predominant part of the rangeland represented the principal obstacle to their development and resulted in overgrazing of irrigated rangeland and its deterioration while non-irrigated rangeland was practically not used.

At present the principles and patterns of rangeland cattle breeding in the Karakum desert have radically changed. Small nomadic individual economic units have amalgamated to make large collective and state economic facilities. A typological study of rangelands has been conducted, their seasonal and annual productivity has been established, possible rangeland livestock breeding patterns have been identified, taking full advantage of the natural fodder resources. The creation of large-scale sheep and livestock breeding facilities has made it possible to embark upon planned utilisation of the territory.

For a number of years in desert areas a lot of work has been underway to re-build the existing irrigation networks and to deliver water to new rangeland tracts. New techniques have been found to maintain and feed sheep under the conditions of round-the-year rangeland breeding. The experimental study of the relationship between grazing patterns and rangeland utilisation and commercial conditions have gone into the formulation of differentiated grazing loads for different desert areas, which ensures preservation of the rangeland. Rangeland rotation has been introduced in the best livestock breeding farms in the desert zone, which makes it possible to adjust the timing and degree of rangeland use representing one of the simple and effective ways to control desertification in these conditions. In recent years some of the best sheep-breeding farms have developed and implemented a system for the use of cultivated rangelands.

In recent years research and scientific institutions in Soviet Central Asia and Kazakhstan have created a technique to improve rangelands, increase their productivity and ameliorate the composition of the grass-stand. To improve desert rangelands a number of scientific groups have undertaken an important and comprehensive ecological study of different types of deserts and their natural environments. The study has identified reserves of moisture, heat, nutrients and other factors, still unused by vegetation. This has made it possible to create man-made phytocenoses from different plant life-forms. Such phytocenoses are more resistant to the desert's adverse conditions and can be used as rangelands throughout the year, while natural rangelands can be used only during particular seasons.

The present day utilization of the Karakum rangeland is based upon a judicious combination of round-the-year sheep grazing and differentiated feeding of animals with concentrated and volume feeds during the difficult winter period. This ensures the necessary nutrition for the sheep and adjustment of grazing loads in different sections of the rangeland, a factor guaranteeing productivity for many years.

DEVELOPMENT OF KALMYK'S BLACK LANDS - A CASE STUDY OF COMBATING DESERTIFICATION

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Regions with "fragile" biogeocenotic ties among the natural components are most vulnerable to different types of desertification.

Desertification particularly affects subarid and arid regions with grassy biogeocenoses on mechanically light soils. Desertification is caused by abusive anthropogenic impacts. Among those the worst and the most intensive one is represented by human impact (through livestock breeding) on hay-fields and rangelands. That is accompanied by human development of land for irrigated land tilling and meadows. These are supplemented by technology-induced complete desertification, long transport communications, oil and gas lines, local desertification around industrial and mining facilities alienating, disrupting and polluting large tracts of land. In principle on the global scale arid territory development excludes desertification.

And yet, desertification does occur as a result of negligence and disruption in the process of development of natural components that go into the biogeocenoses.

The above reasons behind desertification to varying degrees can be observed on the vast territory of South-Eastern European USSR, whose area exceeds 15 million ha. Its sizable portion, more than 8 million ha, is known as "Black Soil". This succient popular definition describes the territory's main characteristic: total absence of, or very rare snow cover, which leads in the winter period to dry grass stands and the emergence of ephemeral vegetation, which facilitates attractive winter rangeland sheep-breeding connected in the summer time with the Alpine meadows of the Caucasus in the Stavropol area, the Georgian Republic and the autonomous republics of Northern Caucasus.

Black soil in the Kalmyk Autonomous Soviet Socialist Republic is developed throughout the year by state and collective farms as hay fields and rangelands. More intensive livestock breeding very frequently by way of overgrazing, alienation of rangelands and hay fields for other uses in agriculture and mining and other industries, the tracking of a railway line between Astrakhan and Kizlyar, the construction of a highway and other factors have resulted in a higher man-induced impact on "vulnerable" rangelands, which began to cause aeolian deflation and the formation of sand dunes and ridges. The construction of the Chagrai water reservoir through diverting the water of the Terek river, the construction of the black soil irrigation canal and intensified output of artesian wells created conditions for irrigated land tilling. In the last 25-30 years forest strips have been planted over large areas. Despite the short time - only 15-20 years - they have assumed considerable importance in desertification control and in creating a better human environment.

The vast changes in the territories, however, have not been objectively or fully reflected on the existing geographic or special maps due to difficulties inherent in the effort- and time-consuming surface cartographic operations.

The need for a cartographic description of basic positive and negative changes resulting from objective regularities in the development of agricultural facilities, their deployment, the effort necessary for continued development of the territory and control of man-induced desertification, has been seenly felt.

One of the important means to overcome the inventory barrier in the study of natural resources and agriculture is an effective application of remote techniques for deciphering space photography maps. The expertise in using those techniques to make such special maps as the maps of soil resources, erosion and deflation processes and utilization of the resources for Kalmykia's black soil covering 8 million ha, is presented below. The scale of all maps is 1:500,000. Use was made of space photographs of the same scale, sets of space photomaps of 1:200,000 scale as well as fragments of aerial photographs at 1:50,000 and 1:10,000 scale, space scanning photographs from the "Fragment" program at 1:500,000 scale. This addition of large-scale fragments was made necessary by nature's distinctions of the territory occurring in the dry semi-desert and desert areas with the preponderance of light, chestnut, brown and solonchak-solonets soils over the large depression of the Manych and Sarpa. The entire territory is characterized by the solonets-solonchak complex creating a vast diversity of soil cover with vast sandy tracts and natural low grass rangeland, psammophytic and halophytic vegetation as well as expanding tracts for irrigated and unirrigated land tilling. In the coastal zone the receding Caspian sea creates young marine soils carrying hay-fields.

The climate is continental with 300-150 mm precipitation annually. Part of the territory is typical waterless sandy loam desert. The basic stages involved in mapping were as follows:

1. Cameral decyphering of space photographs (maps) at 1:500,000 scale; "vague" patches were interpreted from 1:200,000 scale pictures.

2. Field verification from helicopters of contours with debatable properties.

3. Computer-supported interpretation of poly-zonal photographs through the use of photometry to arrive at additional properties used to update certain genetic and geographical regularities in the soil distribution, possible erosion or deflation processes and the way in which the soils are being used.

The most information found useful in interpreting the territory's soil resources came from photographs taken in spring and late autumn periods, following the autumn ploughing. The least suitable were photographs of the post-harvesting period, since the stubble and residual grass-stand distort the tone and texture of the photographs. The condition and utilization patterns of soil resources were best interpreted from photographs taken in spring and summer. The three maps helped objectively identify 17 basic nomenclature units and 19 additional units characterising integral and combination contoure, an obviously unbiassed classifications.

Each particular map carries new information about soil distribution, water and wind erosion and other factors important for economic performance. Deflation seats have been identified in relation to more intensive anthropogenic impacts. The geographic distribution of the processes has also been identified, which helps to pinpoint the areas requiring erosion control programs.

A map describing the present-day condition and utilization patterns of land tracts offers a clear-cut idea as to the extent and type of their development and demonstrates different kinds of development approaches for different geographical and natural areas.

The rate at which land is removed from agricultural utilization suggests considerable gravity of the problem. The maps were made by a team of 6 in a matter of 6-8 months, including time losses. The making of similar maps through surface techniques would have taken 3-4 years by a team 3-5 times the size of the actual one. At the same time our research and the resulting techniques make it possible to monitor soil resources comparing the results with space photographs taken at subsequent periods. The cost of the three maps did not exceed 200,000 roubles. A similar operation through the use of surface techniques would have taken 8-10 times the sum. Experience suggests that already now it is possible to use space photography maps to study and record medium-scale agricultural utilization of natural resources. The effort can only be made successful by prompt delivery of space photographs to the scientists and training of skilled personnel in soil science, botany, geography and forestry.

SIGNIFICANCE OF THE NUREK HYDROELECTRIC PLANT IN THE FORMATION OF A PRODUCTION AND TERRITORIAL UNIT

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Construction of the Nurek Hydroelectric Plant was a key factor in the development of productive forces and in formation of the South-Tajik production and territorial unit (i.e. economico-geographic entity).

With due regard for economic and geographical conditions, a series of hydraulic works was initiated on the Vakhsh River by way of tackling major water management problems. This river basin (39 thou km^2) accounts for 50 per cent of the Republic's water resources. The Vakhsh mean annual runoff is over 20 km^2, the maximum water discharge being 3.7 thou m^3/s.

The Nurek Hydroelectric Plant is now built on the river of 3 mln kW capacity. The complex includes a 300 m high unique sausage dam and the Nurek Water Reservoir of 10.5 km^3 storage capacity, which provides seasonal regulation of the river flow for the needs of power engineering and agriculture.

The Nurek Hydroelectric Plant is the core of the South Tajik production and territorial unit. With ample local labour and cheap electricity, various agriculture-oriented industries came into being here, agriculture represented by cotton-growing, vineyard and citrus culture development and livestock (the Unit is one of the basic areas of long-staple cotton cultivation in the USSR).

The Unit acccounts for nearly 70 per cent of GDP and 90 per cent of the Republic's labour force engaged in industry and in the sphere of production in general.

The 11th Five-Year Development Plan envisages the high rate of productive forces development in the Republic. The Guidelines of Economic and Social Development of the USSR for 1981-1985 and up to 1990 note that in the South Tajik Production and Territorial Unit the construction of Yavan Electrochemical Works will be continued, and production at the Aluminium Plant expanded. The construction of the Ragoon and Baipaza Hydroelectric Plants will reach an advanced stage. The amount of electricity generated in the Republic will be as high as 16 billion kWhr.

IRTYSH-KARAGANDA-JEZKAZGAN CANAL
AND ITS PART IN AGROINDUSTRIAL
DEVELOPMENT OF CENTRAL KAZAKHSTAN

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1. The Irtysh-Karaganda Canal was put into commercial opera-

tion in 1974, while some of its portions became available for temporary operation in 1967. At present the Canal is being extended from Karaganda to Dzhezkazgan. The portion in operation is 458 km. long from the head water intake on the Belaya river, a tributary of the Irtysh near the town of Yermak - to the first up-lift at the Karaganda-Temirtau regional water supply line. The overall water elevation from the Irtysh to the high point in the watershed of the rivers Shiderta and Tsura amounts to 418 meters, the water is hoisted by 22 water works.

2. The Canal lies in the arid steppe of Central Kazakhstan with dark chestnut, chestnut and light-chestnut soils. Its new ramification to Dzheskazgan is characterized by brown soil, Atmospheric precipitation is scarce - less than 220 mm, it fluctuates considerably over the years and does not ensure stable yields of grains or forage on unirrigated land. The local water sources are not sufficient - the local rivers of Nura, Sary-Su, Kara-Kengir and Upper Ishim have an annual discharge (averaged over many years) of 4.01-6.48 million m^3, a 95% reliability discharge is dozens of times lower than the annual discharge averaged over many years, with 95% of the discharge occurring in spring, while in summer the rivers go dry and break down into pools. To utilize that water a lot of ponds and water reservoirs have been built.

At the same time Central Kazakhstan is becoming a site for proliferating mining, metallurgical and other industries, mushrooming cities with vast populations.

Continued progress in industry and agriculture was hampered by failure to provide a steady water supply.

3. The Canal was conceived and built as an integrated many-faceted facility to deliver water to people in the cities, industry and agriculture, while taking full advantage of the available local water sources.

Water requirements placed by the population and all sectors of national economy now stand at 3 billion m^3 annually, the requirement can be met by using groundwater accounting for 0.1 billion m^3, recirculated waste water accounting for 0.35 billion m^3, adjustment of local rivers' discharge - 0.32 billion m^3 and water from the Irtysh-Karaganda Canal - 2.23 billion m^3, representing 75% of the entire water supply. Of that amount 1.9 billion m^3 will go to meet the needs of the industries and the urban dwellers.

4. The Canal plays a major role in promoting agriculture of arid areas in Central Kazakhstan. In the Canal's effective area of 3.4 million hectares 450 thousand hectares have been found to be most responsive to irrigation, the rest of the territory in need of involved land reclamation programs or unsuitable for agriculture due to difficult relief features, shallow parent rock or salt-bearing sedimentation. To ensure delivery to the people in industrial areas of vegetables, potato, dairy products and meat irrigated land is predominantly developed to be used to grow potato, vegetables, forage crops, for cultivated rangeland and hay-fields.

5. As is suggested by the experience of the old and new agricultural operations, sprinkling irrigation, which is absolutely dominant in this area and accounts for 90%, requires irrigation water consumption rates of 2,750 m^3/ha in the Pavlodar region, 3,100 m^3/ha in the Karaganda region. Grass yields on natural ran-

ges in dry years do not exceed 200-300 kg/ha, while irrigation by flooding (State Farm Ekibastuzky, an area of 4,500 ha averaged over 2 years) - 2,000-2,500 kg/ha. Barley yields were 2,100 kg/ha on irrigated land and 370 kg/ha without irrigation, for oats the respective figures were 2,550 and 530 kg/ha, potato - 12,400 and 6,000 kg/ha, maize - 31,800 and 7,200 kg/ha.

6. Conditions for land reclamation are different at different sections of the Canal. The Nura river valley offers the best conditions for irrigation, where irrigation for many years does not result in secondary soil salinization. Here the soil is underlain by a thick layer of sand-and-gravel ensuring natural drainage into the river valley. On the Irtysh Plain made with heavier sedimentation, drainage is essential to remove seepage water (in some areas coupled with removal of drainage water), as are small amounts of phospho-gypsum to prevent alkalinization of soil, especially with soda.

7. To deliver water to rural areas and to large ranges water networks are constructed on a large scale.

A total of 7 network lines to deliver water will be built, whose total length will be 1,593 km capable of delivering 89.2 m^3 of water per day, enough to meet water requirements of 52 state farms and 7 townships and to irrigate 2,440 thousand hectares of rangeland.

8. Integrated approach to construction operations has radically changed the life-styles for the people of the area, opened new vistas for industrial and agricultural development, made the economy more reliable and increased the people's cultural standards.

LARGE IRRIGATION STRUCTURES AND DESERTIFICATION (CASE STUDY OF THE KARAKUM CANAL)

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Desert development represents an important part in the Soviet Union's national economic and social plans. Hydroengineering construction that has unfolded in recent decades, more particularly, the construction of large-scale canals re-distributing the run-off of the Amu-Darya and Syr-Darya rivers, the principle water thoroughfares in Soviet Central Asia, represented a step towards more f-ficient irrigation and prevention of desertification. These canals deliver water to what formerly was water-thirsty fertile land of the delta and piedmont plateaus of Central Asian deserts.

This is exactly the function performed by the V.I.Lenin Karakum Canal, which has been constructed and commissioned stage by stage in the Turkmen SSR since 1954. The Canal draws water from the Amu-Darya river upstream of the town of Kirka and, flowing westwards, ensures stable irrigation of the central part of sub-aeral deltas of the Murgab and Tejen rivers, the northern Kopetdag plateau and will soon deliver water to the west Turkmenian lowland, which will become suitable for growing the best varieties of cotton and valuable sub-tropical crops. In terms of size the Canal is one of the largest of its kind in the world's deserts. It is 1,100 km long with the first 450 km navigable, the maximum head water intake is in excess of 500 m^3/sec while the irrigated area is 550 thousand hectares. Annually the Canal receives 10 km^3 of water from the Amu-

Darya river. When it is finally completed in the mid-1980's it will be 1,400 km long irrigating up to 1 million hectares of land, while 7,000,000 hectares of rangeland will depend for water on the Canal. Its head water intake will increase to 800 m^3/sec while its annual discharge will be 18 km^3. It will be navigable as far as Ashkhabad, or about 800 km.

Prior to the construction of the Karakum Canal, desertification processes in Southern Turkmenia in certain areas assumed awesome proportions. For example, in the deltas of the Murgab and Tejen rivers the oases had repeatedly suffered from a water shortage caused by an unstable discharge of the two rivers. During some years the Murgab's run-off would drop to only one third of its run-off averaged over many years, while the Tejen almost invariably does not have any run-off at all for at least six months. To that we must add that the natural fluctuations of the run-off are at variance with the irrigation requirements. Therefore even during the years with a relatively high water supplying capability cases were frequent when during vegetation watering the run-off fell far behind the mark. As a result the irrigated area in the Murgab delta fluctuated from 70,000 to 100,000 hectares and in the Tejen delta never exceeded 30,000 hectares. Droughts, irregular water supply and drops in the productivity resulted in considerable losses sustained by the agriculture of the oases. A drop in the available water as well as the use of desert vegetation as fire-wood on the brink of the oases led to the advance of quick-sands towards cultivated land.

In the Kopet-dag zone only 30 to 35% of the water requirements were met by the local rivers replenished by rainfall and characterized by an unsteady discharge, also by low debt springs and drilled wells. The overall water shortage was exacerbated by uncontrollable mud flows that caused soil erosion and waterlogging of the soil in the piedmont plateau at its junction with the sand of the Karakum desert. Range livestock breeding (Karakul sheep) in the Karakum desert was supported by only a network of saline water wells and fresh water wells, these latter few and far inbetween. The wells became surrounded with "pinpoint" desertification seats resulting from the trampling of vegetation by livestock and the advent of quick-sand dunes around the well sites and livestock camps.

Following the construction of the Karakum Canal the above desertification phenomena completely disappeared. The impact of the Canal on the surrounding desert was different at the Canal's different sections and depended upon many factors both natural and economic.

In the interfluvial area between the Amu-Darya and the Murgab rivers (South-Eastern Karakum) the Canal lies in permeable sandy sedimentation. The rise in the groundwater table as well as surface moisturization resulted in a radical restructuring of natural complexes in the desert. It became a site of new hydromorphous complexes hitherto known only in valleys well supplied with water and deltas of large transit rivers of Soviet Central Asia analogies of tugai (vegetation covered bottom-land) and saz landscapes. Along the Canal a zone emerged extending laterally 10-30 plus km with a peculiar ecological condition characterized by high biological productivity. Range livestock breeding is now supported by a reliable water source in the form of the Canal and seepage lakes. The wells in the vicinity of the Canal are no longer used and an opportunity has arisen to create emergency forage reserves though the new moisture-loving vegetation and planting of grass (sage-brush on the new watered areas). Small seats of irrigated land-tilling have been created. In mid-stream bisecting the Murgab and Tejen oases the Canal exerts an indirect influence by having its water used to irrigate the new land tracts. The water supply has become stable and controllable, not given to fluctuations in the Murgab and Tejen's discharge. In the Murgab oasis five years ago the irrigated area amounted to 212,000 hectares, in the Tejen oasis - 190,000 ha, the drainage operation that followed the construction of the Karakum Canal ensured in the delta of the Murgab in the early 70's a negative salt balance in the irrigated tracts. (Previously, secondary salinization of the soil in the Murgab oasis, which had been irrigated without the benefit of drainage for many millennia, rendered large tracts unfit for use). Availability of water made it possible to start reclaiming the sand areas adjacent to the oases making them fit for agricultural use. Irrigation stimulated growth in the processing industry. At the same time hydro-power stations rating 1.2 million kW were made operational using the Canal water and natural gas. The power facility supplied the industry, irrigation systems and human settlements with cheap electricity. The fuel problem was solved through developing the Shaklyk gas deposit. Gas cilinders are now delivered to any point in the Republic including remote farms in the Karakum desert.

The advent of the Amu-Darya water to the Lpetdag plateau created the necessary conditions for guaranteed irrigation of the most fertile lands of which more than 100,000 ha have been developed as against 20,000 ha relying upon the local run-off. The natural complexes have not yet undergone such major changes as have occurred in the sand desert, with the exception of new irrigated tracts.

On these latter the previous rarified cover of xerophites and ephemerals was replaced by copious cultivated vegetation suggesting a well planned assault on the desert. The commissioning of the 300 km-long water duct connecting Ashkhabad with Erbent and drawing on the Canal, eliminated livestock breeding's dependence on well water and added grass stands supported by the Amu-Darya water to the natural rangelands. The Canal prevented diffusion of mud-flows on the piedmont plateau. Mud-flow control facilities concentrating the temporary surface run-off will rechannel it via the Canal to the north where the mud will be deposited in the sand. In the future these areas will be developed for agricultural needs.

Therefore the example of the Karakum Canal zone demonstrates the importance of large-scale irrigation facilities as a means to control desertification in the context of a well planned desert development by a Socialist state. Judicious utilization of land purposefully regulated in the interests of the entire society and integrated improvement of irrigated areas in which agricultural facilities are combined with industrial operations, planned economy - all these factors lead not only to control and containment of desertification processes, but also to better utilization of desert's natural capabilities.

TYPES OF ECONOMIC DEVELOPMENT OF ARID AND SEMI-ARID AREAS OF THE SOVIET KAZAKHSTAN

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For many centuries, after the period of Soviet economic restructuring (1920's-1930's), vast territories of what now is Kazakhstan occurring within the arid zone - predominantly deserts and semi-deserts and dry steppe in the North and Southern piedmont area - were used almost exclusively as rangeland. The Kazakhs inhabiting the territory were primarily engaged in nomadic livestock breeding with special emphasis on less demanding fat tail, rough fleece and Karakul sheep, goats and camels (occasionally horses and meat producing cattle). Out of all natural wealth of the arid zone only the most insignificant portion was actually used - the scarce vegetation of sage brush, saltwort and cereals. Not taking full advantage of natural rangeland Kazakhs would move from rangeland to rangeland driving along their livestock and would temporarily settle down in the deserts of Central and Western Kazakhstan in the winter time and in the dry steppe of Southern mountains in the summer depending on the season. During very severe snowy winters and very dry and hot summers when the rangelands were almost totally parched by the sun the livestock would suffer from malnutrition and die out. Overgrazing for many years would render rangeland unfit for further use and turn it into trampled-down clayey expanses of naked wind-blown sand.

Kazakhstan's arid zone had hardly any industry. It was only represented by very few small mining operations: for coal (Karaganda and Ekibastuz mines) and oil (two oil-extracting facilities in the low reaches of the Emba river). There was also a plant in Chimkent by the southern brink of the desert processing santonica ('rtemisia cina) from the neighbouring piedmonts. Caravan and livestock routes were the only transport communications, with the exception of a railway line from Orenburg to Tashkent with very little passenger or cargo traffic.

As a result of the industrialization of the entire country, which was especially vigorous in what formerly was czarist Russia's most backward periphery, including the deserts of Kazakhstan, of a radical reconstruction of agriculture related to settlement of the former nomads and the organizations of hundreds of livestock breeding collective and state farms, the area underwent radical changes, and it was Kazakhstan's arid zone that began developing more rapidly than other areas in terms of industry, transport and agriculture.

What used to be nomadic population became fully settled. Part of the nomads settled to the north and south of the desert zone - in the steppe and piedmont areas. Some of the nomads . ttled down in the arid zone itself wherever there was abundant water or rich mineral resources.

The development of vast and diversified minerals resources in the arid zone (coal, oil, non-ferrous metals, mineral salts etc.) the construction of new industrial operations, communications, collective farms, state farms, canals etc.) involved not only the indigenous population, but people of other nationalities from other densely populated parts of the USSR, such as the Russian Federation, the Ukraine; and Koreans from the Far East who knew whatever there was to know about rice growing. Kazakhstan's deserts and semi-deserts sprang hundreds of new settlements, partially estates of state and collective farms but predominantly industrial townships or tranport junctions and towns attached to mineral deposits or facilities processing them, as well as along the new rail tracks: Karaganda and its satellite cities, Jeskazgan, Ekibastus, later Shevchenko, Uzen, Arkalyk and many others. Formerly this territory, three times the size of France, did not have even rural settlements, with the exception of very small railway junctions along the track, coal mines and oil fields, with a few hundred inhabitants; there was also a small fair town of Karakaralinsk. The deserts were criss-crossed by many hundreds of miles of rail track and highway: Turksib (from Turkestan to Siberia), Guryev-Orsk, Petropavlovsk-Karaganda-Balkhash-Chu-Magnitogorsk, Tselinograd-Pavlodar, Makat-Kungrad and others.

A lot of irrigation engineering work in the arid zone was done resulting in large tracts of irrigated land, with plantations of cotton, sugar beet, rice; orchards and vineyards (the Golodnaya Steppe /The Hungry Steppe/) in the lower reaches of the Syr-Darya, Karatala, Ili, Chu, Talass. Along the northern, partially southern ridge of Kazakhstan's arid zone there were millions of hectares of virgin lands, which later became grain fields, giving birth to hundreds of new settlements, whose water supply was ensured by hundreds of kilometers of water pipe and canal (just like the Irtysh-Karaganda Canal to deliver water to the Karaganda junction).

The rest of the arid zone not covered by industrial transportation or land-tilling development began to be used for range livestock breeding, a more up-to-date technique compared to the nomadic livestock breeding of the past days. The new type of livestock breeding took advantage of the new socio-economic structure and was supported by land cultivation and fully settled population. The sheer size of Kazakhstan's arid zone and the diversity of its natural resources, especially minerals, differences in the landscape and geographical situation of its different parts made it possible for Kazakhstan to become in the Soviet period the site of several types of new territory development and its economic specialization, each of which contributes its own share to desertification control in the arid zone:

A. Development related to minerals utilization. This area is characterised by the processing industry, including ferrous and non-ferrous metallurgy, chemistry, new cities emerge with a complex infrastructure, surrounded by satellite towns and rural agricultural facilities, recreation centers and a well-developed transportation network, developing gradually into a large-scale urban agglomerate. Radical changes can be observed in the cultural patterns, and an improved natural landscape emerges, featuring a man-made oasis in the desert created through planting vegetation, delivering water, construction of canals and water reservoirs and desalination of saline water. A case in point is the Karaganda agglomerate, the cities of Balkhash, Jezkazgan, Arkalyk, Shevchenko and their satellites.

B. Development supported by transportation facilities. This type of development is similar to the preceding one, however it is characterised by a smaller scale and a simpler infrastructure of the small towns and rural settlements. This type is known for considerable man-induced landscape changes and minor changes in the natural landscape. A case in point is the new urban settlements along the rail tracks, such as the towns of Ayagus, Arys and others.

C. Development supported by irrigation facilities. This type of development radically changes the natural landscape, which becomes infinitely better suited for human habitation. Along the main trunk of the Canal and its ramifications appear fields of grain and industrial crops, orchards and vineyards, dozens of large townships, predominantly of a rustic nature and populated by people originally coming from other parts of the country. The territory is supplied with water, planted with vegetation, the desert becomes a cultivated oasis, judiciously managed, with soil salinity tightly controlled. A typical case in point is the Golodnaya Steppe with the town of Zhetysai, the Karatau with the town of Ushtobe, the Chu valley with the town of the same name, and others.

D. Development supported by virgin land tilling. This type is similar to the previous one, however the scale of semi-arid zone development is larger. Basic changes in the natural landscape are not so striking, and the dry steppe was replaced by fields of wheat and forage crops, with the large settlements and farms scattered here and there. A case in point is the city of Tselinograd and its environs, the cities of Aktyubinsk, Pavlodar and others.

E. Development supported by range livestock breeding. This type does not lead to desertification because even a more intensive land use is offset by correction measures, such as rangeland rotation, the growing of forage crops, irrigation, livestock paths etc.

PRINCIPLES OF ESTABLISHING AN AGRO-INDUSTRIAL UNIT UNDER IRRIGATION DEVELOPMENT OF DESERT LANDS

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Land irrigation in arid and semiarid regions differs basically from the reclamation programs accomplished in other regions in this country - and not only by its methods but also by the type of influence it has on the regions' economy and the specific relations that arise between natural conditions, the natural resources involved and the economic relations thus created.

Surely, the reclamation projects installed in the drainage zone or the zone of insufficient moisture change neither the key trend of agricultural production nor the entire economy of the region in question, and the cultivated crops remain the same as before; land reclamation intensifies agricultural production and usually brings yield increases of 50 to 200-250%. The principal effect of reclamation is seen in an acute reduction of the farms' dependence upon the fluctuations of climatic factors and improvement of soil conditions (aeration, drainage, etc.), i.e. man, while making agriculture no longer completely nature-dependent, maintains otherwise the pattern of agricultural production increasing its intensity, productivity and, not infrequently, its quality as well.

Given irrigation in the arid zone, the pattern of interaction with the natural and economic environment changes profoundly.

The recruitment for irrigation of an additional natural resource - water - allows to initiate high-powered agricultural production there but requires a dramatic change to be effected in the development pattern of all productive forces.

Indeed, when irrigated farming is developed in desert areas with dispersed pastoral and desertic, indeed most often transhumant livestock husbandry, it becomes necessary, in addition to irrigation, to amass huge productive assets, build housing and appropriate cultural and welfare facilities to provide normal living conditions for the farm personnel and their families, hoard equipment and stock of material resources, install repair depots, ware-houses and sites, and build roads and supply lines for water, power, gas heat, communication etc.

Moreover, because of the modified pattern and trend of agricultural production, the services and processing facilities also assume a different look.

Advances in agriculture and processing industries and the initiation of new densely populated areas is inconceivable without the development of trade, communications and public services and setting up administrative bodies.

To add here also the substantial amount of work in land irrigation, which is properly the basis of this development, and improvement of natural fertility through drainage, cultivation and leaching, it becomes clear what a vast amount of construction work will be needed for the lands to be successfully developed and the necessary economic and social links to be created. This must be supplemented with the construction of the supporting building and building materials industry called upon to assure the necessary pace and scope of the construction effort.

This the series of projects becomes discernible which are brought into existence by irrigation development in new regions.

In this particular case, irrigation acts as the decisive development factor imposing its own speed, scope and composition of work programs and the primary development trend of the region of new irrigation.

The challenge of bringing new lands under development demanded adaptation of the forms and principles of construction for water management in our country. On the other hand, the country's already installed material-technical base and the increased might of the Soviet state enabled a transition to a new stage in the organisation of construction for water management.

The new zone called The Hungry Steppe seemed just the right kind of an area to streamline, test and incorporate into practice the principles underlying the new, so-called integrated method of construction.

The principles of integrated construction and irrigation development of large new land areas in the Soviet Union's arid zone are based on the necessity for:

- integrated management of natural and recruited (water) resources for multiple uses, in conjunction with optimal development of the region in question, in order to secure maximum gains for the national economy at the minimum expenditure of waters as the foremost resource;

- planned and proportional development in the various sectors of the region's economy, with a view to maintaining the needed rates of agricultural production on the basis of ever expanding irrigation in the leading sector and avoiding non-productive uses (or freezing) of all recruited or created resources and funds;

- setting up a favourable situation for sustained priority growth of the national income in the areas of new development in order to be able, concurrent with the high efficiency of irrigation, to attract necessary human contingents to the new lands;

- prevention of deterioration of natural resources in the process of development and maximum improvement of their potential productivity.

These principles can be adhered to and accomplished, should the irrigation development of a new land area be approached as the formation of a single natural-production-irrigation complex to be seen as an optimal combination of controlled natural resources and a specially installed production and economic base to foster the development of highly productive irrigated farming and all associated sectors.

Discussed in the report is the natural production irrigation complex as a combination of natural conditions and economic formations, with the active participation of natural resources in the complex.

HISTORICAL AND GEOGRAPHICAL ASPECTS
OF DESERTIFICATION IN CENTRAL ASIA

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Historical record of man's impact on the environment of Central Asian deserts (Turanian lowland) comes to several millenniums. During the Holocene period (of major man's economic activity) environmental factors of arid ecosystems of the Central Asian plains have undergone significant changes. These changes undoubtedly affected the processes of desertification in the area under study. Considerable impact on the ancient irrigation systems was caused by migration of the rivers Amu-Darya, Syr-Darya, Zeravshan, Tadjen, Murghab. Climatic fluctuations during relatively warm and cool periods have immensely affected desertification in Central Asia. They have given rise to recurring drying of the territory, change in vegetation and soil cover as well as in topography (formation of dunes and barkhans). Development of the desertification process could be hardly comprehended without consideration of historical and geographical data.

Social and economic anthropogenic factors have influenced desertification in no less degree.

Historical and geographical data obtained for a prolonged historical period along with the latest knowledge of arid ecology serve as a scientific means to combat desertification of lands aimed at reverting desert areas into the sphere of economic activity. Moreover, these data are also essential for the forecasting of aridization processes.

WORLD PRACTICE OF ARID LAND DEVELOPMENT AND COMBAT OF DESERTIFICATION (COUNTRIES OF ASIA, AFRICA, AMERICA, AUSTRALIA)

ENVIRONMENTAL ASPECTS OF DESERTIFICATION PROBLEMS AND THE IMPACT OF MAN - THE EXAMPLE: THE SAHELIAN ZONE IN AFRICA

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The ecosystem of the arid and semiarid zones show a great adaptability to the high variability of the rainfall typical of these zones. The natural equilibrium can, however, be strongly disturbed through the impact of man. The ability of the ecosystem to regenerate itself is drastically reduced. This is the case in the Sahelian zone, where desert-like conditions are being created everywhere as a result of land misuse in the vulnerable ecosystem between the Sahara and the savannah. The degradation of vegetation and the decrease of soil productivity there are due to overgrazing, overcultivation and the irrational clearing of woodlands.

Rain-fed cultivation as a cause of the desertification and degradation of ecosystems

The agronomic dry boundary for millet cultivation is being ignored everywhere in the Sahelian zone. While this climatically conditioned agronomic dry boundary runs along about the 500 mm-isohyete, the actual northern borders of millet cultivation have been pushed as far as the 250 mm-isohyete, i.e., about 200 km northwards. This transgression over the agronomic dry boundary is one of the main causes of desertification in the discussed zone. Air and satellite photos show these desertified areas very distinctly as white or light grey patches in cultivation areas. To cultivate land the inhabitants always clear all the trees and grasses and they systematically weed their fields so that nothing remains except the widely sown millet plants on loose sands. In the dry season (8-10 arid months per annum) the top soil is exposed to strong aeolian erosion. There is hardly any cultivation - fallow rotation to give the soil chance for recovery. The result is the absolute exhaustion of soil and the diminution of its productivity. In the Sudan the crop yields per acre decreased by about half in the last 15 years. To meet the needs of the increasing population in spite of a gradual decrease of millet yields the area cultivated had to be enlarged by three-fold. And so more land has been desertified. In dry years even more land is brought under cultivation to meet the needs of the population so that in the years when the ecosystem is most vulnerable the impact of man is strongest.

This severe impact on the ecosystem is especially effective after drought periods. This was the case after the drought disaster of 1969-1973 when vast areas of the Sahelian zone experienced a strong degradation through irrational cultivation and clearing of tree stocks. The consequences here are long-term and partly irreversible damages. A Plan of Action lays strong stress on rational land use planning, i.e., a reorganization of land use in the affected regions making it more compatible with the natural preconditions (ecosystem). This includes the restriction of cultivation beyond the agronomic dry boundary, the assignment of sufficient area for grazing practices and the control of animal numbers in accordance with the carrying capacity of land. Planning should also provide for the organization of wood-cutting, securing the natural regeneration of trees. This also means the carrying out of plans for the conservation, protection and rehabilitation of vegetation.

ON THE POSSIBILITIES AND PROSPECTS OF SCIENTIFIC APPROACHES TO COMBAT OF DESERTIFICATION IN AFRICA BY INTEGRATED METHODS

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Arid and semi-arid territories account for more than 1/3 of the world's land and a large portion of these territories in tropical and sub-tropical latitudes occurs in Africa. It also accounts for the largest areas of the present-day man-induced desertification. In the 50's and 60's under the UNESCO auspicies a large international program was launched to do research into the earth's arid zone summarizing the maximum of the available information covering the arid part of Africa. The pretracted droughts in Africa in the late 60's and early 70's pinpointed worldwide attention to the current desertification processes and provided a major impetus towards an invigorated international cooperation calling for desertification control under the auspicies of the new international UNEP.

On the whole in socio-economic terms Africa still remains the most backward region even within the group of what is known as the world's developing nations. One of the more important indicators of many African countries' economic backwardness is the level of industrial production, very low not only in global terms, but even among the developing nations. At the same time for more than a decade Africa has been suffering from a persistent and overwhelming food crisis, a widening gap between the production of food and its consumption and growing populations. The challenge of increasing agricultural production and especially delivering food to African countries in the coming decades should be regarded as an important, perhaps the most important economic and social problems for most of Africa's countries.

At the same time the present-day man-induced desertification occurs very rapidly in Africa, in its most backward areas, i.e. in a situation of very scarce local material, financial, scientific, technological and other resources required to formulate and implement effective desertification control programs.

An objective evaluation of the current African situation excludes the possibility of controlling desertification through industrial development of the desert areas. This,of course, does not alltogether rule out such projects per se, however they cannot ensure the basic solution of the problem -to reduce desertification scale, increase agricultural production, especially food production for local needs. One could expect that in most of Africa's semi-arid and arid areas the most promising desertification control techniques would be represented, at least in the foreseeable future, by an integrated nature preservation program designed to restore, preserve and replenish renewable resources for agricultural production, the solution of the local energy problem etc. It can be mentioned in parentheses that discontinued or drastically reduced burning of vegetation as firewood will radically reduce man-induced desertification in Africa.

The heightened interest to industrial projects as a means to control desertification suggests that in Africa as well as in other of the world's arid regions similar projects would prove practicable for areas where desertification makes agricultural projects impossible or too costly. It is obvious, for example, that in Africa's arid regions formulation and implementation of economically viable industries,especially the mining industry,would prove profitable. However this would predominantly cover dry areas that are not too badly affected by the present-day man-induced aridization. These areas can already be identified in and around Sahara where expertise is building up the industrial utilization of mineral resources, predominantly oil and gas.

The above considerations lead us to believe that science - supported plans to steadily control desertification in Africa would call for a comprehensive zoning of Africa's arid areas alongside other research efforts--both planned and implemented. This zoning, which would incorporate the territories' natural distinctions, possible irreversibility of ecosystems as a result of man-induced desertification,the local socio-economic situation and other factors,would be conducive to determining the most promising directions and methods of desertification control,ways to overcome its consequences,the type of economic activity for each desertification seat in Africa and within each of Africa's countries.This zoning would help evaluate specific projects frequently put forward by specialists for different parts of Africa.At the same time the formulation of the zoning principles might represent one of the more rewarding forms of international cooperation involving specialists from Africa's developing countries.The methodological principles of such zoning would be of course applicable not only to Africa,but also to other desertification areas in the world's developing countries.

SUDAN DESERTIFICATION CONTROL
AND REHABILITATION PROGRAMME

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Sudan's arid and semi-arid ecology is mainly determined by the total amount and distribution of rainfall and to a more limited extent by soil type, topography and elevation. Rainfall is unpredictable, highly variable, and extended periods of drought are more the rule than the exception. In other words, rainfall fluctuates and because of this the ecological balance between climatic conditions, vegetation, animal life and soil biota is precarious, and any land misuse pressures will upset it. The damage may be irreversible with severe and continued misuse, which has been the case in the Sudan's marginal lands.

Desertification in the Sudan is a man-made phenomenon caused by such land misuse pressures as overgrazing, irrational cultivation, wood cutting and deforestation, uprooting shrubs for fuel, lowering water tables due to increased water use and burning grasslands, forests and shrublands.

Sudanese scientists, technicians and policy makers know from their own experience and investigations, and from the experience and investigations of others that desert encroachment can be controlled and rehabilitated. Accordingly, a Desert Encroachment Control and Rehabilitation Programme (D.E.C.A.R.P.) has been formulated. The proposed programme of action is based primarily on the premise that desert encroachment is a consequence of man's activities and that man can change his ways to his and society's benefit. In other words, desert encroachment is a human problem and it will take humans to solve it.

D.E.C.A.R.P.'s action programme includes cessation of cultivation on areas susceptible to wind erosion, crop legume rotations in lieu of continuous cultivation, improved cultivation methods and use of soil and water conservation structures, establishment of grazing cooperatives and policies, integration of the range livestock and agriculture industries, rationalized use of rangelands through controlled and deferred rotation grazing, range seeding and improvement, construction of fire lines, integration of water provision and range conservation and management activities, surface and ground water development for small-scale irrigation, water spreading, development of town perimeters, afforestation, sand dune stabilization, development of shelterbelts and establishment of wildlife reserves.

Implementation strategies have been identified and a coordinating and execution infrastructure has been formulated.

DESERTIFICATION - THE TANZANIAN SITUATION

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Tanzania, which lies between latitudes 1° and 12°S, provides a good example of a tropical country with an equatorial climate that is affected by moderate to high degrees of desertification hazards. Not much is known about the actual extent or rate of desertification but a number of important studies are being undertaken. These, coupled with work being done by the Forestry Department and the on-going campaign of educating the people in the rural areas on the importance of afforestation, are gradually increasing our understanding and awareness of desertification and its social and environmental implications. Estimates show that between 25 and 75 per cent of the country, receiving a mean annual rainfall of 2000-8000 mm, is susceptible to desertification, the primary afflicted areas being the semi-arid central part of the territory including the region surrounding the new capital of Dodoma, the lake Victoria basin (Sukumaland) and the Masai country stretching northward to the Kenya border. In the central belt, desertification is revealed in "the stripping of the top - soil, accelerated run-off, gully erosion on slopes and/or sheet erosion or deposition in flat lands". In the northwestern semi-arid areas of Sukumaland, the symptoms include "the stony or rocky surfaces subject to areal stripping by deflation or sheetwash". In central Tanzania, the number of people and cattle has increased dramatically and quasistatic agricultural methods have been adopted without proper soil and water management systems for this low rainfall area. The vegetation has been highly degraded and the land rendered sterile and useless to man and beast. Soil erosion and sedimentation have affected river catchment areas, the worst afflicted district being Kondoa-Irangi, where badland topography has developed, with innumerable gullies and sand-choked rivers criss-crossing and mantling newly cultivated fields. Pilot studies on sedimentation rates in four reservoirs in the Dodoma region and one in Arusha have revealed annual average sediment yields of 200-700 m^2/km^2, high enough to cause some of the reservoirs like the Ikowa and Matumbulu to be silted completely in only 25-30 years.Much of the desertification in Sukumaland is due to overcultivation,poor land management and the wholesale repetitive clearing of vegetation, especially during the anti-tse tse campaigns initiated by the British colonial administrators in the 1920s. In the northern part of the country, the principal cause of desertification appears to be overgrazing.The situation has also been compounded by periodic bush fires like the recent one(October 1979)which destroyed some 10,000-20,000 ha on the slopes of Mt.Kilimanjaro.The threat posed by excessive collection of wood for charcoal and firewood for both domestic and industrial uses (such as curing tobacco) is becoming serious. Between 1959 and 1970, for example, the total fuelwood consumption in the country increased by 35 per cent and it is estimated that charcoal consumption alone will increase at an alarming 1,000 per cent from the 1970 levels of 0.5 million cubic metres to some 5.6 million cubic metres per annum by the end of the century. Tree felling is twice as much as it was fifty years ago. Attempts have been made in some parts of Tanzania to arrest the situation, but the country has yet to formulate and embark on a coherent, systematic and coordinated programme of development in the degraded semi-arid areas as a whole. In some districts, there have been a notable interest among local people to establish village woodlots or small tree shambas, but production and swift distribution of seedlings, periodic outbreaks of bush fires, illegal poaching for fuelwood and unrestricted grazing and browsing by domestic animals have been limiting factors. The Ministry of Animal Production and Natural Resources has established tree seedling nurseries in many parts of the country and has distributed hundreds of thousands of various species for planting to the villages. In cooperation with the Institute of Adult Education, it has recently mounted a campaign to educate people on the dangers of desertification and the importance of afforestation. In the Dodoma region, the Ministry has established an ambitious conservation programme called HADO (Hifadhi ya Ardhi Dodoma) under which, to date, some 7,500 hectares of denuded land have been reclaimed in Kondoa, Mpwapwa and Dodoma districts through a special tree planting and terracing programme. Action plan at the national level to arrest desertification includes the formulation of a national land policy, carrying out land capability studies, preparation of regional and physical land use plans, reduction of fuelwood consumption by using alternative sources of energy, control of soil erosion and overgrazing, promotion of popular participation, training of environmental managers and encouragement of research. There is also the need to develop methods for monitoring environmental impact to discover, counteract and control desertification. Finally, the basically single set (tree planting) remedial measure and piecemeal, sectoral approach being applied towards the solution of the whole problem of dryland environmental degradation-and-recovery in the country at present, should give way to a more concerted, comprehensive and integrated approach. Development and management of traditional resource systems in marginal lands need careful planning.

EVALUATION OF DESERTIFICATION IN EGYPT

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The advancing deserts threaten the Egyptian agriculture to a great extent. According to the world map of desertification Egypt is located within the arid to hyper arid zones and the risk of desertification is high to very high. The situation has been made worse by the following factors:

1 - Egypt is largely agricultural and the Egyptian economy depends very much on land. The agricultural sector contributes to about 30% of the GDP.

2 - The pressure of increased population combined with the scarcity of the cultivated areas which forces people to ask more of the land than it can give.

3 - The absence of Nile alluvium after the High Dam. The great importance of the Nile alluvium was its ability

to defend the fertile cultivated soils of Egypt against the desert attack.

4 - The damage may be irreversible with the severe and continued misuse and poor management, which is the case in the marginal lands in Egypt.

The "Plan of Action to Combat Desertification" adopted by the UNCOD opens with a recommendation that desertification should be assessed and evaluated, both in terms of a continuous monitoring of the process and the evaluation of specific situations.

Apart from the land use or mususe, the specific situation in Egypt that needs to be considered is the fact that the desert sediments are continually added to the fertile cultivated soils of the Nile Valley and Delta, either by torrents, winds or gravity, forming an interference zone of desert and alluvial sediments.

This study brings together all the studies that pointed out the danger of increasing attack of the desert against the soils of Egypt with special reference to the situation of desertification in the fringes of the Nile Valley and Delta.

The indications of the danger of desert attack and the urgent and long-term measures to avoid the damage or stop the progress of desert are presented and discussed in this paper.

THE DESERTIFICATION AND AGRICULTURAL RESOURCE PROBLEM IN JORDAN

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Agricultural resources are very important to Jordan mostly due to the fact that the major part of the country is desert and only 13% of the total area receives an average annual rainfall exceeding 250 mm. The country's imports of food are twice the local production. Since other resources are also scarce, degradation of agricultural resources puts a remarkable stress on the possibilities of Jordan's economy.

The causes of soils degradation are as follows:

- plowing of hilly and sloping lands;
- overgrazing;
- plant removal;
- unwise activities along streambeds;
- floods;
- drought;
- nature of land use.

Sharp increase in the population of this country - due to mass migration of Palestinians from Israel to Jordan in 1948, 1956 and 1967 has resulted in an enhanced food demands of this country and contributed to greater pressure on its farming and rangelands. The city and village expansion, being carried out mainly on good agricultural lands is but one reason for desertification in Jordan.

Even a more serious problem is soil erosion, chiefly on hilly and sloping lands which started in the early fifties with the introduction of mechanisation. The major mistake committed in this regard was using the tractor to plow against the contour lines, which was easier, and by way of the disc plow and mould-board instead of the duck plows and contour plowing practiced earlier with the help of animals. Such practices carried on for about 30 years leave in many cases bare rocks with little or no soil on top. Among other unwise land use practices were farming of marginal lands (in areas with less than 200 mm rainfall) and a shift from grape to cereal production in mountainous areas which occured due to destruction of Jordan's vineyards by insects.

Increased pressure on land resources combined with specific climatic and soil conditions, i.e. short rainy season with strong thunderstorms and droughts (once in few years) and loose soil structure with thin organic layer - have led to numerous flooding (during the shower period) and acceleration of natural erosion processes.

Uncontrolled overgrazing, particularly of goats, in the desert and mountainous areas worsened by the migration of livestock across the borders from Saudi Arabia, Iraq and Syria presents another serious problem leading to disapearance of most suitable grasses in some areas.

While in the early years of this century most of Jordan's mountains were covered with forests, heavy cutting of trees initiated with the construction of Saudi railways exposed major portion of soil to erosion in these areas.

Estimates of total losses of soil due to different causes suggest that 2.5 thousand hectares of Jordan's soil resources have been lost every year for the past 50 years.

Jordan's next Five-Year Plan Development (1981-1985) includes the following projects aimed at resource management and desertification control:

- Land Capability Mapping Project;
- Range Development Project;
- Highland Development Project;
- Natural Afforestation Plan;
- Soil Conservation Project in the Zarqa Catchment.

THE IMPACT OF INTRODUCED TECHNOLOGY ON DESERTIFICATION IN THE ARAB COUNTRIES

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During the last century the arid and semi-arid lands of the Near East and North Africa were inhabited and exploited by nomads. Their main resource of living was a primitive dry farming sufficient for subsistence, plus sheep and goat herding. Transhumance and migration during the wet and the dry seasons was a necessity for existence. Nature was limiting the number of inhabitants and livestock severely.

Recently, through the introduction of tractors, vast areas of arid lands have been ploughed each rainy year. The natural vegetation which afforded fodder for sheep and goats is now destroyed and the soil is left to the mercy of wind and water erosion. Owing to the fact that the rain is not sufficient for dry farming each year, these arable lands are lost to the desert.

The introduction of motorized transportation of the animals to any part of the arid lands and the possibility of using tankers to deliver water subjected the whole area to overgrazing and early grazing. The impact of man on marginal areas increased through the use of trucks. The result is an advance of the desert.

The introduction of drilling in search for underground water opened new possibilities for living and livestock husbandry in marginal areas. Irrigated agriculture flourished in some parts by these means. But the ignorance of nature possibilities brought about some catastrophes. Through pumping water in the water-shed areas many springs ran dry and whole villages with their fields were deserted. The desert was waiting to take over.

The ecosystem in arid areas is a very delicate, balanced and fragile thing. Before we learn to understand it we have to be very careful in exploiting it. The pressure of human race increase and the improvement of life standards is asking more products from arid lands in the Arab countries. It is our task to think of an adapted technology suitable for these areas to save them from desertification.

RECLAMATION OF ARID LANDS
IN THE ARAB COUNTRIES

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The Arab Center for the Studies of Arid Zones and Dry Lands - ACSAD - has particular interest in the studies of natural resources in the Arab countries. The arid area represents an important part of the Arab World. More than 87% of the total area has less than 150 mm. rainfall. The development of agricultural resources takes into consideration problems related to aridity and desertification. Reclamation of arid lands deals with salinity, high water table, drainage problems, crop rotation, land management and many other problems. ACSAD's experience shows that an integrated development for combating desertification should be based on national, regional and international cooperation.

Several examples could illustrate this cooperation. The studies in Deir El-Zor Station are carried out by ACSAD with the cooperation of the Ministry of Agriculture and Agrarian Reform and the General Administration for the Development of the Euphrates Basin, deal with irrigation and drainage techniques, the water requirement for field crops,cotton and sugar beets, the nutritional aspect of the main crops under salt affected soils and land management and crop rotation under arid conditions.

Other examples could be specified, e.g. the Human Project, the Seed Multiplication Project and the National Park at El-Kouf in Libya.

Preliminary results show that technology is available and could be applied where and when cooperation is possible between the countries themselves, the national, the regional and the international organizations.

A SUMMARY OF YEMEN HYDROLOGY

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Physical Conditions:

Yemen is located at the southern tip of the Arabian Peninsula, between the latitudes of 12°14' and 68°.

The major part of the country consists of two mountainous chains, one runs north-south from the south of Saudi Arabia to the PDRY and the second from the Red Sea to Oman.

It is under a maritime influence in the west, coming from the Red Sea and in the south from the Gulf of Aden. It is under a continental influence in the east coming from the desert of Rub Al Khali and in the north from the Middle East Peninsula.

Although the country is small in size (135,200 km^2), it has a high variety in hydrological conditions, because of the combination of its topographic features, climatic regime and geological formations and structure.

We can define 5 major water resources units:

1. Eastern Lowlands: It is a part of the desert of Rub Al Khali, the yearly rain-fall is less than 100 mm, and the groundwater is usually at a great depth and often saline, unless it benefits from the recharge of wadis coming from the highlands.

2. Eastern Midlands: This zone is lying between 1000 and 1500 m, and has yearly rainfall which is lower than 200 mm; however perennial streams are found in the major wadis of the watershed. The ground water of good quality is usually found in the alluvium valleys and plains built up by these wadies. The precumbrian formations are dominant, although they have not yet been studied thoroughly. From present experience it seems that their aquifers are poor in quantity and quality.

3. Highlands: Although the rainfall is higher (between 300 and 900 mm) the occurrence of surface water is limited to some springs and small perennial streams, the steady source of supply is groundwater. The extraction of groundwater has been mostly limited to the alluvium basins from hand dug wells, until the introduction of the drilling techniques, which has been opening up the access to the deep aquifers of the hard rock. The sedimentary formations are found usually in the northern part and range

from good to poor aquifers, the Cretaceous-Tertiary sandstones are best, the volcanic formations of the central and southern part are not very reliable, but the Quaternary formations have usually some good aquifers.

4. <u>Southern uplands</u>: They are the region which receives the highest rainfall (up to 1000 mm). Therefore, water is available in perennial streams and numerous springs.

The groundwater has been largely developed in the alluvium plains but due to physical constraint (high gradient or hard rock) and the abundancy of rain, the groundwater has not yet been fully investigated.

5. <u>Western Lowlands</u>: It is the alluvium plain stretching from the Saudi border to the PDRY border called Tehama. It is traversed by seven major wadis which enter into the Tehama as perennial streams but infiltrate into the alluvium before reaching the Red Sea. The recharge from these wadis is feeding "Wadi type" aquifers which are usually of good yield and of good quality of water. The feasibility of the digging in the alluvium and the shallow aquifers allowed an important development of these aquifers by means of hand dug wells and this has been reinforced during the last 20 years by the use of pumps and motors. The introduction of tube wells in the

Tehama appeared in the last years, but they are still limited because of their prohibitive cost. Salt water invasion of aquifers near the Red Sea is of increasing concern.

SITUATION IN THE WATER RESOURCES ACTIVITIES:

The country has faced an "economical boom" since 1974, from the remittance of the migrants. The new cash flow has been partly invested in irrigation wells, or its domestic use water projects. As a consequence, the number of drilling companies, local as well as foreign has been tremendously increasing from 10 to over 75 within 4 years. However, if the cost of drilling was very high during the first year, it went up to $900 per m in the year of 1978, it is now coming down to an average cost of $300 per m.

Similarly the market for pumps and motors opened up but the diversity is very limited. Motors are usually of Japanese make diesel v. electric type with a power of 20 to 23 Hp and the pumps are limited to a few brands and a few types. The existing situation in the market restricts considerably the possibility of matching the wells with the pumping units. It is not unusual to find wells with pumps or motors which have a power at least double of what is required.

From the foreign assistance side, more than 20 bilateral of multilateral agencies are funding over 50 water projects throughout the country. These water projects are either domestic water or rural water supply or irrigation schemes. As a consequence of the diversity in the origin of the donors there is a high diversity in the standards of design, type of equipment and strategy involved in implementing these projects. Furthermore, since the market is not ready to supply a large choice in the equipment and spare parts, the majority of these projects are facing problems in the maintenance and in the continuity of their activities.

PROBLEMS OF THE WATER RESOURCES CONTROL AND EXPLOITATION:

There are nine governmental agencies dealing with water activities as it can be seen in the Table 1. Most of them have been created within the last 15 years to meet the short - term needs of the fast development of the nation in the agriculture and drinking water fields. But it is coming to a point where the institutional responsibilities of these agencies are now and then overlapping and therefore decreasing their effectiveness in carrying out their respective duties. Although the need for a national water resources council or a Co-ordinating Council to solve the conflicting situation has been pointed out by some of these agencies, it has not yet been created officially because of the existing highly comple institutional situation in this field (refer to Table 1).

Besides the institutional problem, an effective control of the water resources has been hindered by the lack of studies of the hydrogeology of the regions and of the monitoring of the exploitation of the ground water. Although some limited regions have been covered during the implementation of water projects, the water resources of the major part of the country remain unknown therethus, making less effective any implementation of water laws, since the regional water balances are not fully defined.

GROUNDWATER OF NORTH ARABIAN DESERTS AND ITS UTILIZATION

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Northern Arabia is located in the subtropical desert belt that is remarkable for its hot and dry climate. Vast stony and rarely sandy deserts are found within this spacious territory, namely: Syrian, El-Hadjara, El-Hammad, En-Shaamiya, Dibdiba etc. Severe natural conditions, shortage or absence of reliable sources of industrial and domestic water supply make it difficult for man to live and earn his means of subsistence. Therefore, an integrated study and development of deserts, their multiside use of rich natural resources is but a common goal for all countries (Jordan, Iraq, Quwait, Saudi Arabia, Syria) of this region. Thus, one of the first priority tasks is the study of groundwater resources and elaboration of the scientifically-grounded programme of their utilization under conditions of water-deficient deserts.

The territory under study is, in the context of structure, the northern edge of the Arabian plate coinciding with an immense natural reservoir (basin) of groundwater. Several water-bearing complexes have been revealed in the recent years within the upper hydrodynamic floor of this basin. They coincided with depositions related to periods from triassic to contemporary and distributed regionally. The most water-abounding rocks in the Syrian and El-Hadjara deserts are fissured and cavernous limestones and dolomites of upper Cretaceous period, Palaeogene and Miocene. Well productivity in these sediments amounts to 4-17 l/sec reaching 89-113 l/sec within the zones of disruption. Subsurface waterbearing layers are usually of higher salinity. Fresh groundwater is developed within the valleys of intermittent streams in sandy areas. However, the major resources of fresh and low-salinity groundwater are formed at a depth of over 100 m within the areas composed of cavernous limestones and in the zones of fractures which serve as natural regional drains. This zone of fractures is characterized by a flow of fresh groundwater while water of higher salinity (1.0 - 2.5 /l) is spread beyond its boundaries. Thus, the zones of tectonical disruptions are promising in the surveying of possible fresh groundwater in the deserts of Northern Arabia.

Wells of 100 to 1000 m depth are the main water-intake devices. Production wells are equipped with immersion pumps. Groundwater intake in different regions of Northern Arabia increases every year. The isotope composition of groundwater in that area reveals that the present replenishment of its supplies under arid conditions is negligible. Therefore, increase in water intake can result in considerable depletion of unrenewable groundwater supplies. This sets forth a necessity to implement a number of measures to conserve and rationally use the groundwater resources.

IMPACT OF IRRIGATION ON NATURAL VEGETATION IN RAJASTHAN

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Irrigation by the Gang Canal (1928), the Bhakra Canal (1954), and the Rajasthan Canal (1961) in the north-western parts of the Thar Desert of Rajasthan has converted the once uninhabited waste land into humming agriculture fields. Irrigation involves greater human activity in a particular area and brings about fundamental changes in the landscape, soil composition and its water content, as well as transformation of micro-climates and their heat balance. The natural vegetation, which is the outcome of long adjustments and adaptations of plant species having evolved in harmony with the changing environment, is indiscriminately cleared from command areas. Weeds are introduced through the Canal water or as contaminants of seeds. There is a heavy pressure of livestock on uncommanded areas, which are overgrazed. In addition, the woody shrubs are exhausted for fuel wood requirement. Use of insecticides and pesticides brings further imbalance in the irrigated area.

Irrigation in dry and arid regions results in an accumulation of soluble salts and at places even water-logging may also take place. Improvement of water relations is the only remedy for such soils, otherwise it will ultimately jeopardise the plant survival. Haloxylon salicornicum and Sueda fructicosa native plants can be utilized for reducing the salt content of saline soils.

While introducing exotic species in an irrigated arid tract, its competitive value against the indigenous species and other utilitarian aspects should be examined. Owing to the over-exploitation of natural vegetation for grazing and fuel wood purposes, there is a danger of their fast disappearance and so the genetic pool of natural vegetation of such specialised habitats should be maintained so that they may be expanded as need arises.

In the Gang canal and the Bhakara canal system, there is no provision for afforestation and pasture development programmes.

A proper balance should be maintained in the command area, afforestation area, and the pasture development programmes. Some areas should be left undisturbed for natural vegetation to propagate.

For water-logged areas, lift irrigation and plantation of fast transpiring plant species would be useful.

Where dams are constructed on the rivers, the river-beds downstream can be utilized for the plantation of plant species good for fuel and fodder purposes.

INTEGRATED DEVELOPMENT FOR SIESTAN DESERT IN AFGHANISTAN

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The great inland basin extending over 20,000 square kilometers,. known as SIESTAN, lying along the Iranian-Afghan border, is the biggest desert of Afghanistan. Historical studies show that the area was inhabited for centuries and numerous ruins of forts and villages confirm that this area was once thickly populated and highly cultivated. Desertification has been caused by vagaries of Helmand River, moving from one end to another in the delta, and flooding of vast areas causing immense damage to agriculture and economy. Today, the area is an isolated community, incapable of self-improvement.

Integrated development plan to combat desertification in this area can change the desert to a granary of Afghanistan. Taming the flows of Helmand River which has for 75% years, over 2.76 billion cubic meters of unused water passing through the deeply cut river channel, by irrigation and flood control schemes, conservation measures, sand dune fixation, and rangeland development, can bring this area to glory again.

The Democratic Republic of Afghanistan (DRA) has launched a comprehensive plan to combat desertification in this area. A multipurpose dam built on the Helmand River has put to use about 2 billion cubic meters of water which is less than 50 per cent of the run-off at the dam site. The dam, built with crest at El.1050 meters above sea level has an open-cut spillway on the right abutment, at El.1033. Storage is thus not taking place in top 17 m of the reservoir. A new spillway is under construction to install 8 regulating gates and raise the storage level at El. 1048 and increasing the stored water by 1 billion cubic meters.This will not solve the problem. The solution lies in an integrated development approach comprising:

a) flood control measures,

b) irrigation of the arid land,

c) appropriate drainage measures,

d) communications,

e) agricultural and supporting services.

DRA has started a flood control scheme (Kamal Khan Flood Control Project) near the tail of the Helmand River, which comprises the construction of 2 low-diversion dams and about 20 km of dikes, with provision for irrigation canal off-takes and a small hydro-power station on the main diversion dam, but the problem is tremendous in magnitude, requiring considerable institutional and financial support.

The paper discusses the main features of the Siestan Desert and the proposed measures to convert the desert to a granary.

PROBLEMS OF INTEGRATED ECONOMIC DEVELOPMENT OF INDIAN DRYLANDS

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Investigation of economic development in the arid regions of India may well provide significant basic inputs for generalization of the experience available to date in the overall development of arid regions and control of desertification in the specific conditions of the developing countries. In India, arid territories account for 60% of the total area and feature a variety of types, from extreme aridity in the Thar Desert and those of the highlands to the numerous regions with unsteady moisture supply.

As in most other developing countries, India's arid and especially desert regions are the most backward ones in the socio-economic sense. Rajasthan, Kutch and Kathiawar that form the north-western, most arid zone in India, represented formerly a conglomerate of multiple small feudal princedoms in the colonial period. Nowadays this is a zone of low-productive agriculture, largely non-irrigated farming and transhumant pastoral livestock husbandry.

Rapid population growth against poor diversification of the sectoral structure of the economy in the arid regions and the limited potential of a few cities for the absorption of rural population leads to a direct increase of the demographic pressure on the areas' unstable ecosystems. What is more, the process is going on with a noted acceleration. Commencing the 1920s, the population growth rates in Rajasthan, the state holding the major area of the Thar Desert, has been steadily running ahead of the national average.

The lead took on a significant new scope in the 1950s, reaching maximum in 1971-81 (32.36 against 25.7%). The Rajasthan population grew from 14 million in 1941 to 34 million in 1981, with over 8 million of the total increment falling within the last decade; the average density of populated arid regions.

These socio-demographic processes are accompanied by the vigorous plowing of marginal lands and reduction of grazing lands against a continually growing livestock population. The multiple price increases of petroproducts in the 1970s caused faster cutting of tree-shrub vegetation for fuel in the peasant farmsteads. In sum, these constitute the principle anthropogenic factors of socio-economic backwardness subverting the normal restoration cycles of renewable natural resources and responsible for the ever increasing scope of desertification. Some estimates put at 70% India's arid territories now being afflicted by some or other landscape degradation factors.

By the efforts of the Central Research Institute for India's Arid Zone in Jodhpur, International Institute of Semiarid Tropical Cultures in Hyderabad and other research centers, extensive knowledge has been accumulated to date concerning desertification control procedures and methods for optimization of the use of land and water resources and improved productivity of crop husbandry.

The knowledge deserves special investigation and dissemination. Yet experience has shown the poverty of the major mass of the land-poor and land-less peasantry to set a principal barrier in the way of "diffusion of novelties" (the latter feature commonly relatively higher capital requirements).

Improvement of the desertification control procedures and progress of irrigation cannot be seen therefore as the only way to break the vicious circle out of socio-economic backwardness, poverty and degradation of nature.

By the scale of irrigation development India ranks among the world's leading countries, having a total of irrigated lands equal to 21 million and 35 million hectares, or 17.6 and 24.6% of the cropping area, in 1950-51 and 1976-77 respectively. According to official estimates, when its irrigation potential has been fully utilized, the proportion of India's irrigeted lands can be brought up to 50%. For all that, some of the most developed regions like Tamil Nadu, Gujarat, Punjab and Haryana are approaching total depletion of water resources including groundwater runoff. A vital challenge there is to optimize the use of water resources by all possible means, whether technical (so far around 40% of the water in the irrigation network is lost through evaporation) or more complex and integrated, relying primarily on the comprehensive development of the river basins. Yet these problems are far from being resolved. In common with other countries, India needs to develop a science-based justification for the grandiose projects aimed at inter-basin diversions of river discharge, and installation of a single country-wide water system and the latter's correlation (coordination, prioritization) with the means now available to maximize the recruitment of local and regional resources for these purposes.

Even ith complete realisation of the irrigation potential, the greater part of India, including its arid zone, cannot be provided with irrigation. The country set itself the task to incorporate the "green revolution" into the non-irrigated farming zone, yet the problem is hard to solve because of the ecological conditions there. The primary tool to ward off the continuing pressure on the ecosystems and prevent desertification is seen in the diversification of production on the basis of industrialisation, the move able to divert part of the population from agriculture and set up conditions for agricultural upsurge on the industrial basis and for general acceleration of socio-economic progress.

Whatever industry is now existing in the arid regions is disintegrated and low in production scope. The dominant sector is a handicraft rural industry which supports the existence of relatively closed and underdeveloped village communities; there are individual mining centres in Zawar, Khetri-Singhana and Kho-Daribo and some processing industries operated on local contents(textile, sugar, creameries etc.). In total, Rajasthan, for example, accounts for a bare two percent of the country's industrial output. The larger cities in Rajasthan - Jaipur, Udaipur, Jodhpur, Bikaner etc., all of them former capitals of the like-naked princedoms, are loosely connected with one another and the environs. A classic example of "dualism" taken to mean here a production and territorial gap between a metropolitan centre and its backward agrarian environment is Hyderabad, the capital of the Andhra Pradesh state, a millionaire city located in the centre of Telenghana, a lagging arid region. In the years of independence a new large sea-port, Kandla, was built in the south-east of the Kutch Peninsula. Yet the efficient operation of the well-equipped port runs up against the economic backwardness of the territory gravitating to it.

Inter-sectoral integration on a territorial basis (of the industries and of industry with agriculture and other sectors) seems to be one of the necessary ways to diversification and economic upsurge in the arid regions. The latter could be more effective if combined with the consolidation of the production base of the cities, expansion of their capacity to absorb rural migrants, and envigoration of their links with the agrarian environment. The latter would stand a lot to gain from revival of the medium and small towns.

Poor provision of energy resources and stifling energy deficit hinder industrialisation and general economic progress in the arid regions. In India efforts are being taken to expand their energy base, as a nuclear power plant was commissioned in Rajasthan, design work is in progress for a nuclear-powered agro-industrial complex in Gujarat, and biogas installations find increasing application in rural areas. Nevertheless the problem of energy supply remains largely unresolved and calls for more vigorous efforts to increase power supply for industry, provide adequate fuel for villages, and harness new sources - solar and wind energy.

Upsurge of poorly developed areas is proclaimed as a key objective of regional planning in India. A Programme for Drought-Prone Regions has been underway since the mid-1970s, in addition to special development programs designed by the governments of the eight states holding arid territories. Almost every year the central Government allocates funds to give aids to the drought- and flood-stricken regions. Apart from some duplication of effort between these programs, one cannot help noticing that their approach to the problems concerned with the upsurge of the arid regions and control of desertification is not comprehensive enough, with particularly little attention given to the social basis of the anthropogenic factors of desertification. Neither is the institutional mechanism designed to put these programs into effect or their scientific justification anywhere near adequate. Apparently the complexity of the problems to do with the upsurge of the arid and other underdeveloped regions is such that they cannot be handled "in isolation". Rather they demand special attention as part of the system of the country's socio-ecologico-economic zonation for planning purposes.

The twenty-year experience of cooperation between Indian and Soviet geographers in the development of zonation for planning reveals broad potential for the application of Soviet scientific and practical achievements in the field of regional planning to the specific conditions of the developing countries.

THE ROLE OF TECHNOLOGY INFORMATION TRANSFER IN INTEGRATED DEVELOPMENT

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Desertification data banked in the several existing world systems dedicated to this type of information testify that there has never been a lack of scientific research attention paid to this phenomenon. Information resources go back several generations, and the basic research further back than that. The failure, therefore, to implement the various plans of action: international, regional, national, local, has not been due to lack of knowledge but rather to cultural, educational, and political obstacles. It is increasingly important, therefore, to institute some mechanism by which technology information transfer is employed in integrated development schemes dealing with desertification. On this front at least we may hope to create the impetus necessary to begin the forward motion the situation requires.

On an international basis, the transfer of technical information is now not only quite possible but is actually operational in several instances. There is no technical reason, therefore, why a global arid lands information system cannot be achieved for the benefit of those many countries totally or partially characterized as arid. Among these are the several plagued by desertification, even though they are not deserts in the conventional sense. The wealth of information already available about how to cope with this degradation of land so desperately needed for food production would, through such a system, enable the inhabitants of those areas to begin to take on the responsibility for management of their land resources themselves, even though the political boundaries of such areas may overlap. Integrated attacks on the problem regionally would tend to stabilize many aspects of the situation because the information on which the regeneration was based would be directly related to local problems, focussed specifically on immediate projects tailored to current needs.

The diffusion of within-country technology must be viewed not just in terms of an act of transfer but in terms of the act of integrating many elements of action traditionally administered separately. While the blessing of separate governments would be required initially to get such integrated action underway, the education and training of field (extension) workers would be based largely on a combination of their local experience and the information network output that our international system would provide. Within such a framework, international special training centers envisioned by Dr.Kassas might be necessary to begin with, but eventually - sooner than later - such special training would be carried forward by the application of technology information transfer to the local level where conditions are such that the transfer is productive and appropriate.

Such a system, whether operational electronically or via satellite networks, would cut through the bureaucratic red tape that has paralyzed many of the countries represented at the Nairobi conference, would substitute action for talk. It would enable countries in need to make maximum use of existing facilities and available materials (thus reducing waste), and would utilize abundant unskilled labor by replacing inappropriate mechanical or machine-powered jobs by manual operations (with attendant economic benefits) - these advantages achieved through the application of information already available and needing only dissemination.

Dregne's Law ('If a technology looks as though it is immediately transferable, look again') notwithstanding, we propose that the transfer of technological information can be assimilated by local/regional inhabitants of an environment that is shared in common. The special training required to analyze such information and determine if it is appropriate must be the prerogative of those persons whose experience and empathy for those served is established. The transfer of information through high technology to the level where its practical application is not only possible but acceptable to those served because it is understood in familiar terms is the challenge that we can meet successfully if there is the will to do so.

I am ready to begin. Are you?

PRACTICE OF ARID AND SEMIARID LAND DEVELOPMENT IN LATIN AMERICA

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Arid and semiarid areas claim extensive spaces in Latin America, mostly on the Pacific coast and in north-east Brazil. Climatic aridity, as a factor in the aridization of a territory, becomes evident also in other regions and countries of Latin America. Sustained agriculture there requires irrigation, primarily because of the acutely pronounced seasonal pattern of precipitation.

Experience of Latin American countries in the productive utilization and new development of such regions has undisputed importance, above all for the countries of Africa and partially of Asia, as well as for the development and implementation of a realistic and science-based international programme concerned with combating desertification through regional development.

This experience commands interest for several reasons. Firstly, most of the known types of the world's deserts are presented in Latin America. Secondly, the region has a many-century history of productive utilization of arid and semiarid areas whose source can be traced back to the remote past, as the ancient Indians had already devised many original types of irrigation. Thirdly, almost all of the socio-geographic patterns of natural resource management and types of arid and semiarid regions, from the simplest single-purpose to the complex and integrated ones, are known to occur in Latin America.

There exists an interrelation between the need to get rid of the effects of anthropogenic (man-caused) desertification and the expansion of a state sector in the economy. The challenge of combating the consequencies of devastating droughts induces the state to create a special mechanism in order to bring under development arid and semiarid regions. Brazil's example is quite illustrative as its drought control inspectorate, founded back in 1909, had been one of the first organisations in the stat sector. The hazard of increasing anthropogenic desertification influences also regional state policies. E.g. a development authority for North-East Brazil, one of Latin America's most backward regions, was instituted following the strong drought of 1958. After droughts descended in the late 1960s and early 1970s agricultural development programs came underway in North-East Brazil. Yet thus far they have valled to yield the effect expected in Brazil, not least for the reason of ever increasing regional disproportions in the character and speed of capitalist development. The arid and semiarid regions of Latin America are characterized by rather diverse and potentially promising combinations of natural, among them mineral, resources. They are particularly significant in the arid coastal zone in the West where the vast complex-ore deposits of the Pacific ore belt occur side-by-side with mineral raw materials for the chemical industry and the land and agroclimatic resources of the coastal plains and foothills. Directly adjacent to them are river basins with massive quantities of water resources, the fact making possible interbasin diversions of a part of the river discharge into the arid and semiarid regions. It has also far-reaching implications for the development of the arid and semiarid territories without a single large river flowing into the ocean there. In South America (Equador and Peru) these areas occur in comparatively close proximity to extensive sources of oil and gas.

The territorial combination of natural resources provides a great potential for integrated regional development of the arid and semiarid ranges in Latin America where the single-purpose utilization of the surface runoff for irrigation is predominant.

The principal regions or irrigated farming are found in the Pacific zone. These are North-West Mexico and North Peru - the areas where capitalist commodity farming has been progressively advancing and the capitalist relations dominate the economic scene. The extent of integration in the development of the economy, on the whole, is not large. E.g. on the Pacific coast of North-West Mexico, one of the country's most dynamic regions after the Second World War, large-scale hydro-engineering construction projects are not accompanied by the construction of power plants.

Latin America is already well underway on some separate integrated regional development projects in the arid and semiarid territories. These can be exemplified by the Olmos Project in Peru, currently being carried out in cooperation with the USSR. There, diversion of water from the Amazon basin over the Andes will set the scene for closely interacting large-scale hydro-engineering and agro-industrial complexes to serve the latter's industrial operations. Actually a system of settlement, and the basic and social infrastructure, are being created anew. An integral economic region of national significance is gradually taking shape there, whereas in the areas of single-purpose utilization of water resources it is sectoral regions as a rule receiving priority in development.

Economic development of the arid and semiarid regions and control of anthropogenic desertification have enormous significance for Latin America. This applies above all to Mexico, Peru, Chile, Colombia and Brazil. The development of their arid and semiarid land spaces is growing into an essential economic and social challenge confronting a large group of Latin American countries - their politics and regional development.

DESERTIFICATION IN PERU

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One fourth of the total land area in Peru, or about 30 million ha, is generally recognized to be arid or semiard. The area's population accounts for 80% of the country's total and it concentrates almost all agriculture, industry and mineral production. Thus the country's development is squeezed into a narrow zone and occurs within the framework of the development models specific to arid lands.

The principal feature of the arid and semiarid zones in Peru is their geographical variety. On the one hand, there is the coastal area, a narrow arid strip partitioned into more than 50 oases or transverse valleys which concentrate a little over 8 million inhabitants and 800 thousand ha of cropping areas, of which 300 thousand is affected by salinity and water-logging in consequence of the seasonal and irregular pattern of river discharge and excessive irrigation of farm crops. On the other hand, the presence of the hinterlands of the Andes or Sierra, both of them mountain ranges dissecting the area into thousands of "islets", has been and still is an obstacle to progressive development of Peru. In this traditionally underdeveloped region with a population of seven million desertification assumes a dramatic character due to the high population density on the cultivable lands, the latter's irrational use and primitive soil treatment methods, coupled with the overuse of high-mountain ranges and the disturbances brought about by the mining industry.

The Government of Peru shows legitimate concern for the problems of desertification in the arid, semiarid and subhumid regions. In an attempt to prevent it, work has been done to reclaim the saline and inadequately drained lands on the coastal plains; legislative measures have been taken to discourage forest cutting on the north coast and the medium and small irrigation systems have been modernized and updates introduced into the system of land use in the Peruvian Andes.

At present, with the goal of policy formulation in the conservation of natural resources, a fundamental law to that effect is being drafted as first priority; research is being done in basic sciences such as physical biology, technology and economics; and education and training is undertaken including personnel training in appropriate numbers in the field of natural resource management. Finally, the public consciousness is being educated to the need for sparing attitude towards Nature.

REGIONAL ASPECTS OF DESERTIFICATION
IN PERU

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The problem of desertification is of destruction of the land's biological potential resulting from irrational use of natural resources by man. This process damages the productivity of agricultural ecosystems and forests thus leading to their irretrievable loss, i.e. to destruction of vegetation cover.

Almost 2/3 of the earth surface lies within the arid and sem -arid zones, where humanity faces complicated problems of desertification and where the lfare of about 80 mln people has limited prospects for further development. The annual desert increment rates are 7 mln hectares which threatens the total area of 3,760 mln hectares.

This problem grew up to a global one during severe drought in the Sahel zone in 1968-1973. Similar disasters but of lesser scale took place in the other regions of the world, as, for example, in arid and semi-arid zones of Peru.

The action to prevent this disaster have been undertaken on the national level in different countries both before and after the UN Conference on Desertification.

These include: land reclamation, construction of irrigation and water projects aimed at expanding agricultural production areas, afforestation and integrated development of new areas.

As regards the latter, we've got a good example of desert zone development in Central Asia of the USSR, where the construction of the Karakum Canal gave a possibility of expanding agricultural areas and at the same time to establish a corresponding (agroindustrial) industry and accelerate the urban and industrial construction on the basis of potential resources of the area (like glassworks, fertilizer production plants, textile industry based mainly on sheep breeding).

Antecedent events

Pre- and Ink civilizations in Peru have risen in the desert, high-altitude arid zones. Later on, Spanish colonizers have settled in the coast plains with arid climate and also in different regions of the semi-arid zone. Social organization of Ancient Peruvians and technology of water management with the help of irrigation structures enabled to develop lands for cultivation of different crops and to utilize water to the utmost.

On entering Peru, the Spaniards considerably interfered with the existing land use pattern due to predatory exploitation of mineral resources. Increase in timber use had resulted in large-scale deforestation and triggered intensive erosion and desertification. Development of pastoralism resulted in destruction of vegetation on natural meadows and in 500 years have brought forth severe water erosion and intensification of desertification in the highland regions.

Actual problems

At present arid and semiarid lands occupy an area of 30 mln hectares (23.3% of the country's area) in Peru and cover three existing natural regions with concentration of national industry, agricultural production, mining industry and major cultural centres.

The Coast of Peru with the population of 7,800 thousand people and area of 144,004 km^2 (11,2% of the country's area) is a region economically suitable for utilization! agricultural development is feasible on 10% of the total area (1,400 thousand hectares) which represents a shortage of agricultural lands due to arid conditions. Current cultivated area including irrigated lands is located in 52 narrow valleys and makes up 770 thousand hectares including about 306 thousand hectares (40%) that are subject to salinization and insufficient drainage problem. It should be added that major agricultural enterprises are also located in these valleys.

Sierra or mountainous region occupies an area of 335,170 km^2 (26% of the total area) with the population amounting to 6,550 thousand people. Altitudes vary from 1,200 to 6,800 m over the sea level. Agricultural activities and population are mostly concentrated at the altitudes of 2,000-3,500 m where cultivated area makes up 1,750 thousand hectares including 500 thousand hectares of lands left living fallow, thus, cultivated are only 1,250 thousand hectares. Theoretically, this area should satisfy the demand of population in agricultural products.

Selva region covers an area of 806,041 km^2 (62.7% of the total area) and is populated by 1,650 thousand people. It can be divided into two subregions - Highland Selva with forests on the eastern slopes of the Andes and Lowland Selva or Amazonian lowland with flat and undulating topography. The total cultivated area makes up 590,000 hectares.

Both Highland and Lowland Selva are subject to severe desertification. Thus, in 1975 forests were cut at an area of 4 mln hectares in these two subregions. Besides, deforestation in the provinces of Satipo and Chanchamayo covered an area of 400 thousand hectares while in Oxapampa - 300 thousand hectares.

To partially compensate the land losses due to desertification there have been designed large irrigation projects aimed at the increase of agricultural production. These are: Chira-Piura (153,500 hectares), Chao-Viru (116,800 hectares), Olmos (80,700 hectares), Majes-Siguas (60,000 hectares).

There is also a project under consideration named "Ecological Management of Desertification in Peru" that stipulates for production systems management and determination of desertification indicators and its causes.

Similar situation is studied by the regional project "Combating Desertification through Integrated Development".

PROBLEM OF DESERTIFICATION OF THE ARID COAST OF PERU

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Peru is situated in the western portion of South America, its area 1,285,215 sq km and population 17.800 thousand. The physiographic conditions are determined by the Andes, the mountain system dividing the country into three natural regions - the coast, mountains and selva.

The coastal region which is the principal concentration area for the greater part of industrial and agricultural production and the population, represents essentially an arid zone.

The most important factors of climate and topography, such as the West Andes, anticyclone of the south Pacific, and the Peruvian and Equatorial streams, are responsible for the arid character of the coastal climate.

The soils of the coastal area are controlled by three geomorphologic units, namely, alluvial irrigated valleys, plains and hills, and uplands and moderately high mountains. The region's water resources are limited because of the modest size and irregular pattern of runoff.

In the coastal area, desertification is caused by the following factors: <u>salinity and inadequate drainage</u> on an area of about 306 thousand out of the 770 thousand ha of total cropping area; <u>availability of water</u>; non-uniform distribution of water resources and the latter's wasteful use and pollution; <u>water erosion</u> essentially seasonal in character and closely interrelated with floods; wind erosion; on irrigated lands there exist also the problems of sand drifts burying irrigation channels, blowout of seeds by wind, and dune formation; destruction on the dry tropical forest on the northern coast occurs as a result of irrational livestock grazing, and wood cutting for fuel and for parquetry production; insults to the hills, their surface area 100 thousand ha, have the flora and fauna severely damaged by overgrazing, shrub overcutting and uncontrolled hunting; management of agricultural lands for other uses, mostly for populated areas.

The arid zone is second in importance after the mountain province of Sierra (semiarid) both in terms of sown areas and livestock numbers, and the share in the gross national product. At present, the Coast is going through a period of vigorous economic development, financial, political and administrative revival, and an upsurge of culture and services.

Peru belongs to the countries with a very low per-capita rate of land areas (0.20 ha per person). With this in mind, special importance is attached to the progress of the agricultural sector where large investments are made in irrigation development. With the goal of reclaiming saline and inadequately drained lands, the REGATIC plan (Reclamation of Coastal Lands) involves a wide-ranging program of their reclamation.

Presently, there are numerous examples of skilful application of desertification control procedures including sprinkling irrigation, salinity and drainage monitoring, land conservation, afforestation, etc. Yet the procedure does not provide in itself an effective key to combating desertification; to do so, it must have the support of economic and social structures and vigorous involvement of the population at large.

Mining, another economic sector, is acknowledged to be the strategical industry for national development, being the major single source of currency for the country. It is heavily concentrated in the Sierra mountain country and somewhat less on the coast.

Industry, one of the most dynamic sectors of the economy, is found, for the most part, in the coastal zone. In 1974, for example, the coastal zone held 86% of all industrial operations accounting between them for 90% of the total economically active population employed in industry. The essential areas of petroprocessing are situated on the northern coast and, before oil exploration began in the selva, 95% of the oil supply came from that area and the continental shelf. Growth of folk handicrafts is also important for the coastal region and other areas in the country.

In 1972 47% of the country's population was concentrated on the coast, chiefly because of its migration from other areas which caused a reduction in the rural population overall.

In the absence now of an integrated approach to national development like one exercised until recently, the peripheral areas sustained damages, leading to severe overpressure on the rural and urban ecosystems. Regional development programmes seek to accomplish a number of objectives and thereby provide solutions to the problems of employment and higher living standards, but beyond these, to offer ever greater possibilities for attaining integrated regional development including here control of desertification as an essential goal of national and regional development.

MONITORING OF DESERTIFICATION IN WESTERN ARID ZONE OF INDIA

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A case study on desertification in Luni Block of Western Rajasthan covering an area of 1,900 sq.km undertaken in 1979 at the behest of UNEP provided corroborative evidences of manifestations of the process of desertification on a temporal basis (1958 and 1976) in terms of geomorphological, geohydrological, soil and soil fertility characteristics and vegetational metamorphosis.

Having established the manifestation of the process of desertification the need for monitoring the process arises involving appropriate modern technology for quick appraisal for taking timely combat measures before real onset of desertification. To this end feasibility of using Landsat imagery for mapping earth resources and monitoring of desertification was studied by 1) interpreting natural resources of Rajasthan and surrounding regions on a false color composite mosaic, 2) semi-detailed mapping of earth resources and monitoring of desertification from one scene covering Middle Luni Basin by both visual interpretation and digital analysis.

Visual interpretation of Landsat false color mosaic of Rajasthan and surrounding regions in conjunction with ground data led to the delineation and mapping of nine geomorphic units, twenty-two soils, and four major drainage systems.

Semi-detailed studies in the Middle Luni Basin helped to delineate and map fourteen landforms and their associated soils. Landform and geology are among the most observable resources on the imagery in all multispectral bands with band 5 providing a clear view of topography and slope. However, band 7 proved ideal for observing joints, structures and lineaments on the rocks. Soils could be interpreted only by associated features of landforms. Similarly vegetation per se could not be discernible but in association with landforms eight major plant communities have been identified.

MSS band 7 was ideal for sharply separating water bodies from surrounding areas. Conjunctive use of Landsat imagery and ground data permitted quantification of geomorphological characteristics of the drainage basins in different landforms and also the establishment of two groundwater potential zones viz 1) the recharge zone (Donor Zone), 2) the recharged zone (Receptor Zone).

The false color composite was very useful for mapping the present land use in both irrigated croplands and rainfed areas. Sand dunes were observed with greatest clarity in MSS band 7 and imagery of dry/cool season helped differentiate the stabilized from the active dunes.

Digital analysis of MSS data facilitated quantification of earth resources such as range biomass estimation, distribution of sand dunes and interdune plains, alluvial plains, water bodies and vegetation. The interactive Image 100 system helped to classify seven themes in Subscene I covering Bhetnada-Mori-Manana-Kankani Sector and six themes in Balesar Sector. In both cases there was good correlation of the spectral classes to the integrated land units identified by ground surveys.

Tone and textural characteristics in the Landsat false color mosaic of Rajasthan and surrounding regions did not show any evidence of the spread of desert sands from the west to the east.

Evaluation of imageries of the Middle Luni Basin helped to quantitatively detect, delineate and map the desertification process such as wind deposition and deflation hazards, water erosion and natural and man-induced salinity problems.

The relative brightness values of light and dark pixels in MSS band 5 computer overstrike printout map of a subscene in the western sector of the Middle Luni Basin has been beneficial to delineate different degree of vulnerability of areas to desertification processes.

As further sequel to the above studies the National Project on Monitoring of Desertification to field test the three critical desertification indicators,namely the physical, biological and social factors in different agro-climatic zones of Western Rajasthan are currently under way which has given useful results in fulfilment of the objectives.

PAST AND FUTURE OF THAR DESERT

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The Thar Desert is one of the most populated arid zones of the world. A series of pre-historic cultures once flourished in it. The Indian desert has resisted orogenic forces and has been subjected to marine transgressions. The aridity has established in the region after a series of wet and dry phases.

Climatic deterioration as evidenced by the analysis of aridity indices and implications of escalation of human and livestock populations have been discussed. It is evident that cropping on marginal lands has increased during the past two decades by about 54 per cent as a result of which the area of pastures has declined. In Asia as a consequence of biotic interferences, it is revealed that about 9,290 km^2 of 4.35 per cent of the western Rajasthan has already been affected by the processes of desertification. 72 and 19 per cent of the desert has been categorised as highly and moderately vulnerable to various deterioration factors, respectively.

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A number of cost-worthy and feasible technologies have been developed to revegetate the denuded arid-lands, to augment their productivity, with a view to improve the social economy of the desert people. The future plans of desert development are outlined with a critical appraisal.

DESERTIFICATION IN IRAQ

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Iraq is a land of great contrast, characterized by: vast desert, extensive alluvial plains, low undulated hills, high folded mountains and rugged thrust zones.

From a phytogeographical point of view, the largest part of the country is situated in the Saharosindian region. The naturally sparsely developed natural plant cover has, still, been largely reduced due to overgrazing, cutting of trees for fuel or charcoal and mismanagement.

Desertification in the country is largely man-made through: overgrazing, overcutting of trees and shrubs, cultivation of steep slopes, cultivation of submarginal land, salinization due to irrigation without drainage and land mismanagement. Beside other factors which induce desertification such as: long season of dryness, vast flat areas without wind breaks, fine granular surface soils and high speed in dry seasons.

Most processes of soil degradation are quite active in the country. It is estimated that more than 90% of the land is degraded through various processes such as water and wind erosion, salinization, and physical degradation which includes loss of structure or unstable crusting of the soil and formation of plow-layer.

Various means are applied at present to combat desertification such as: earth dikes, wind breaks, covering the dunes with soil, spraying of petroleum by-products and network of dry plants and branches on the dunes. Also an agro-industrial project is suggested to combat desertification in the Mesopotamian plain.

"VESSEL" TECHNIQUE OF IRRIGATION

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Agriculture and Forestry Survey has applied an irrigation technique based on the use of a vessel.

The given technique consists of digging a long varnished clay vessel into the soil up to its orifice. The clay vessel is filled with water. Vegetable crops are planted around the vessel. This technique has the following advantages:

- easy technique of water supply regulation;
- sluicing regime impeding development of salinization;
- the vessel is manufactured from local raw materials (clay from Grand Dude).

According to the data of KAMAL Central Institute of Soil Salinization (Penjab, India) the daily watering norm of the gourd family cultivated by this technique amounts to nearly 0.20 mm/hectare.

SOME ELEMENTS OF ANALYSIS OF THE ALGERIAN STEPPE

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The Algerian steppe zone is bordered by 400 and 100 mm/year isohyets giving way to desert in the south.

Total steppe area makes up 200 thousand km^2 or 64.5% of the North Algerian territory and 7.8% of the total country's area. It corresponds to nearly 20 mln hectares of which 15 mln hectares can be efficiently used mainly for sheep-raising under assumption that with cattle population of 6 mln animals the carrying capacity makes up 2.5 hectares per one animal.

Nearly 18% of the total population of Algeria inhabits the steppe zone. 170 thousand families of that number are engaged in pastoralism (20,000 in cattle-raising and 150,000 in sheep-raising). The analysis of the sheep-raising production for the period from the beginning of the century suggests that there is a depression trend. Total sheep population has decreased compared to the growth of human population. The paper contains a table of sheep population per one person illustrating its dynamics: 1876 - 403 sheep, 1891 - 223, 1901 - 196, 1931 - 83, 1976 - 47.

The reason for this reduction is grounded in the historical, social and economic conditions and is incorporated in the system and structure of production.

The similar crisis is typical not only of the steppe zone but also of agriculture as a whole.

The adoption of the Agrarian Reform of 1971 contributed to overcoming the crisis.

ELABORATION OF INTEGRATED ECONOMIC DEVELOPMENT PROGRAMMES FOR ARID AREAS

ELABORATION OF AN INTEGRATED PROGRAMME OF ECONOMIC ARID REGION DEVELOPMENT

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Formulation of an integrated problem is, in fact, elaboration of a final and major document for pre-plan research, a science-supported guideline for all specific events and actions designed to develop an arid region. An arid region in this case should, as a rule, be understood as an integral territory possessing aridity characteristics and selected as an object for integrated economic development. The document includes three basic sections: identification and delimitation of an arid region, overall concept of economic and social development, general development principles and territory planning in regions.

A. Identification and delimitation of an arid region. Identification is isolation of a specific distribution area selected for comprehensive development. Delimitation is the precise contouring of the area. An important question arises of the relationship between the identified and contoured arid region and the entire system of the country's administrative and territorial division principles. If the region does not coincide with the administrative unit, forms should be devised to harmonize management.

Internal taxonomic classification of an arid region is also carried out calling for identification of sub-regions different in their natural and economic conditions. These internal taxonomic territorial units are included as elements and objects in the overall development plan and plans for specific regions.

B. Overall concepts of integrated region development. The overall concept of integrated development is the sum total of fundamental theoretical premises, methodological approaches, major development objectives for the region and ways to implement them. The concept rests upon an in-depth study of a specific situation in the territory, its natural ecologic and resources conditions, economic and social factors, internal and external relationships. The following problems are looked into - forms and types of the present-day development in desertification processes, their causes and forecasting-fundamental problems behind socio-economic development of the region, forecasting of future trends, choice of objectives, - characteristics of water, power, raw material, manpower and other resources that will be factored into the ways and specifics of objective implementation. Economic and technological programs to de-desertify the territory, development's driving forces - (the state, cooperative or pettycommodity sector, national capital, foreign capital) sources of finance, deadlines for the completion of the entire program and its first stage.

C. A general development plan and regional planning. A general plan is an estimate-supported forecasting model for the development of economy and population of the region. It includes subsections dealing with the development of industry, agriculture, production, social and engineering (nature conserving) infrastructure, as well as industrial and agro-industrial complexes, population distribution patterns and urban development. All subsections mentioned, and each specific one generalizes all the programs called for by the distinctive features of the arid region' nature-conservation programs, forms and types of monitoring, management and control of natural ecosystems etc. The general plan is accompanied by the major balance calculations for water, power, raw materials and other resources, the system and order of program implementation and financing, overall calculations of economic and social effect of the program at different stages of its implementation.

Regional planning of an arid area supported by the calculations from the general plan specifies all the macro-regional parameters and elements in terms of their siting over the territory. Regional planning as well as other elements in the integrated development program makes allowances for the step-by-step program implementation. Appended to the integrated program for regional development is a set of principles to manage the implementation processes. These principles must take account both of the most advanced expertise in managing programs and projects of this kind and the specific socio-economic and political conditions of the host country.

ON REGIONAL SCHEMES OF INTEGRATED DEVELOPMENT IN THE CONTEXT OF COMBATING DESERTIFICATION

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At the suggestion of the USSR delegation to the UN Conference on Desertification, held in Nairobi (Kenya) in 1977, the Plan of Action included a recommendation on efficient combining industrialization/urbanization with the development of agriculture as a priority measure in combating the desertification process. Such an approach is in absolute agreement with the UNEP overall policy under which integrated development alone can and should ensure the protection and improvement of the environment.

In the framework of the UNEP/USSR Project "Combating Desertification through Integrated Development" among other things a preparation of special guidelines is envisaged for drawing up regional schemes of integrated development in areas prone to desertification. The "Guidelines" are intended to segregate and accommodate in a system the basic principles underlying the integrated approach to planning social and economic development for purposes of combating desertification; to reveal the true meaning, the phasing and most important methodological peculiarities of regional integrated development schemes and environment protection.

The "Guidelines" consist of three sections and of appendices. The first section treats of general statements concerning natural resources, social and economic potential of arid lands as well as the most essential causes and consequences of desertification. It is noted that the natural resource potential of arid lands is determined by the features of climate, the presence of vast areas, by the diverse natural sources of energy, minerals and considerable biological resources. Desertification is shown to be conditioned by two groups of factors - natural and man-induced.

The main natural factors of aridization are aridity of climate, deflation processes, low surface runoff, soil salinization, thin vegetation with low primary productivity. The major man-induced factors of desertification are overgrazing, tree cutting, mismanagement of natural resources, uncontrolled tourism and recreativity. Particularly dangerous is coincidence of natural and anthropogenic factors in time and space.

The second section of the "Guidelines" discusses most essential factors and conditions responsible for stabilizing and neutralizing the processes of desertification as envisaged by a complex of technical, economic, social and ecological measures, including industrialization and urbanization of arid lands. Local measures are shown as incapable of ensuring complete and final success in the fight against desertification, which means that combating desertification is impossible without a well-established system of planning and a machinery for the implementation of plans. Regional schemes of integrated development of arid lands must be based on the following major principles:

- the schemes must be integrated with national development plans forming part thereof;
- ecological, social and economic planning must be integrated in the regional schemes;
- the schemes must be integrated, i.e. they must encompass all industries and types of activity in the region;
- priority in combating desertification must be given to ecological approaches and nature-conservation measures;
- integrated development schemes must include a system of measures to constitute a reliable basis for combating desertification: agriculture development, industrialization, urbanization, development of transport and engineering/technological infrastructure, environment protection measures.

The third section of the "Guidelines" contains methodological recommendations for the preparation of regional schemes of integrated social and economic development and environment protection for combating desertification.

Regional schemes of integrated social and economic development and environment protection for arid lands are viewed as important components of regional plans, as pre-planning documents scientifically substantiated, on whose basis major development problems of particular regions are determined and a complex of interrelated measures is elaborated to ensure a most efficient expansion of economy, social sphere, environment protection within the region, all these measures being desertification control-oriented. In view of the interdisciplinary, comprehensive and purposed nature of the problems solved by regional schemes, it becomes necessary, while preparing these schemes, to make use of territorial, integrated, ecologo-economic and systems approaches as being most adequate to the substance of integral documents of this nature. The practical tool for regional scheme elaboration on the basis of the above-named approaches is a programmed-objective approach, which makes it possible not only to concentrate on the major problem, i.e. combating desertification, balancing the aims and ways of their achievement with the resources, but also to use as far as possible economic and mathematical modelling and computer techniques. The closing section of the "Guidelines" discusses some of the requirements to the organisation of the data bank and environmental monitoring.

P O S T E R   P A P E R S   O F   T H E   S Y M P O S I U M

METHODS OF STUDY AND COMBAT OF DESERTIFICATION

COMPILATION OF THEMATIC MAPS OF DESERT ZONE WITH APPLICATION OF REMOTE SENSING DATA

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Remote sensing is an effective means of investigations of desert environments and their changes under the impact of desertification.

The Aeromethods Laboratory of the Institute of Deserts of the Turkmen Academy of Sciences has compiled a series of thematic maps for the territory of Turkmenistan with the application of space imagery (landscape, geomorphological, soils, geobotanical, rangeland and erosion maps). The erosion map, in particular, represents several types of wind and water erosion, which is of great value for the elaboration of measures for environmental conservation.

Application of space imagery enabled to specify the physiographical background and details of thematic maps. A series of special maps compiled for a single area could be regarded as one of the stages of environmental monitoring. In the course of environmental changes due to human impact these maps should be renewed.

The study of plant phenology permitted to define the optimal seasons for aerial and space survey of the USSR deserts. The most apparent contrast between the components of desert landscape is observed in spring. Aerial and space imagery obtained in this season is most informative. In the South-Eastern Karakum this period lasts from March 20 to April 20; in Central and Zaunguz Karakums - from 1 to 20 of April; for Kyzylkums - from 5 to 20 of April. In the deserts of southern Kazakhstan the recommended period of aerial and space survey lasts from April 20 to May 5.

We have also determined the optimal spectral bands for aerial and space surveys in relation to the tasks that could be solved by thematic mapping. The visible spectral band could be used to obtain the data on geomorphological structure of desert landscapes, species composition and phenology of vegetation, wind-erosional status of sands (600-700 nm). Imagery of the near infrared band (700-900 nm) is useful for the study of floodplain landscapes, water erosion, floods, mudflows and processes taking place within the bordering zone of oases and deserts. In some cases multiband survey should be carried out in two bands (visible and infrared).

Aerial and space imagery can be used for the study of different classes of elements: global (low-resolution imagery), regional (medium-resolution imagery), local (high-resolution imagery) and detailed (extremely high resolution imagery).

USE OF SPACE DATA FOR MAPPING HYDROGEOLOGICAL CONDITIONS AND THEIR MAN-CAUSED CHANGES (WITH THE EXAMPLE FROM THE UZBEK SOVIET REPUBLIC)

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Effective management and planning of protection, rational use and renewal of water resources derives an important data input from maps showing their current condition. The maps therefore should be maximum objective in outlining the status of water resources as of a certain period of time but in addition must be compiled within as short a time as possible, i.e. using high-speed methods. These requirements are accommodated in the maps produced on the basis of space photography data.

The South Aral Sea area, South-Western Kyzylkum and a part of the Ferghana valley were selected as first-priority sites to map out the current status of ground water and anthropogenic changes of the hydrogeological situation. These sites provided a testing ground, as it were, to develop a methodology whereby space imagery could be utilized for hydrogeological and engineering-geological purposes.

Nevertheless the use of remote-sensing data for the study and mapping of ground waters and their associated processes is only possible with the aid of a landscape-indication method.

Effective management of groundwater protection against depletion and pollution, based on the interpretation of space imagery, requires that a series of thematic maps be readily available as consisting of a landscape-indication or landscape map; a ground-water map; a map of land use and current land status; and a map of anthropogenic changes in the hydrogeological situation.

Of these, the landscape-indication map depicts the area distribution of landscape groundwater indicators and those of hydrogeological conditions.

The landscape map is compiled by means of direct interpretation of space imagery. The distinguishing feature of the landscape interpretation methodology has to do with the identification of taxonomic units "top-down", i.e. from the general to the particular.

Direct interpretation clues, such as the figure of a photographic image produced by mega- and macroforms of relief, come handy in identifying the largest landscape units corresponding to the morphostructures of the Ist order. Further subdivision is already undertaken within these units by the images specific to the mesoforms of relief and lithogenic foundation of landscape.

Further hydrosensing interpretation of the landscape map proceeded by means of precomposed, supplementary specific landscape - hydroindication tables, similar in form to the tabulated legend of the landscape-indication map.

To be found on the ground-water map produced by the remote-sensing method from space photography data (through the hydrosensing interpretation of the landscape or landscape-hydroindication map) were:

- lithological-genetical types of water-holding rocks;
- depth to the first aquifer (water-bearing horizon);
- extent of ground-water salinity;
- principal hydrodynamic ground-water areas - those of recharge, transit and discharge;
- various water outcrops (as identified on space photographs to be either watering wells, or clumps of phreatophytes, or the wells and boreholes known from the history files).

In order to detect the extent and character of anthropogenic effects on hydrogeological conditions, the map of land use and current land status was used as an aid. Prepared from the inputs of direct visual-instrumental interpretation of space photographs, the map, for the purpose of studying the anthropogenic changes afoot in the hydrological situation, should essentially reflect all reclamation programs with special reference to those related to the water resource allocation, viz.:

- installed irrigation channels and collector network;
- water storages and discharge lakes along the perimeter of oases;
- allocation of lands of new and old irrigation management;
- condition of irrigated lands (secondary salinization or water-logging exposure);
- distribution of watering points on the ranges supporting transhumant livestock husbandry.

As a series of experimental thematic maps was produced for the Uzbek Republic's plains using space imagery, the key phases of the process flowchart were worked out to be as follows:

Ist stage - preliminary interpretation of space photography data:

1. - preliminary landscape interpretation of space photographs and development of a landscape scheme on the photoplan (a scheme of natural units);

2. - construction of landscape-indication table reflecting landscape inter-relation;

3. - composition, on the photoplans, the series' thematic map overlays (those of landscape and landscape indication, groundwater, land use, etc.).

2d stage - verification of the interpretation effort for its quality and acquisition of supplementary factual data relying on the traditional working methods, ground and aerovisual.

3rd stage - compilation of the final author's (initial) originals of the thematic maps in the series:

1. - compilation of the author's originals of the maps on the photoplans and a lighter topographic base, and legends for them;

2. - achievement of consistency and editing of the maps (in the former it is the landscape map used as the master map);

3. - writing explanatory notes to the maps and requirement to their correct delineation procedures.

SPACE MONITORING OF DESERTIFICATION
IN DELTA ECOSYSTEMS

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To plan programs to combat desertification, it is first of all necessary to define the areas affected by, and the rate of desertification. Study of desertification processes is especially important in the deltas and valleys of desert rivers and in oases. The space-and-time structure of desertification was determined at the example of the Amu-Darya river. The methods and results of the analysis are presented below. The most effective technique for the monitoring of the space-and-time structure of the desertification process is furnished by a comparison of aerial and space photographs of the delta taken at long intervals (comparison of aerial photographs 1:20,000, space photographs at resolution of 70-80 meters and field observations at intervals of 8 years -

1962-1970-1978). Aerial and space photographs help identify dynamic indicators of delta desertification such as increase in the area of halo- and hydrohalomorphous phases and a shrinking in the area of meso- and hydromesomorphous phases with a relative error not exceeding 10% and area changes no less than 2%. This technique incorporating surface field observations and the results of aerial and space photography furnished trend vectors for the condition of 16 basic ecological phases of the delta for three different observation time periods - 1962, 1970, 1978. Comparison of changes in the area of these phases over the years and calculations of the extent of these changes furnished a picture of changes in space and time. These three measurements can provide a judgement as to the trend in the phase changes: linear descending, ascending and stable, exponential ascending and descending; and oscillating. A quantitative description of the present-day changes in the ecological phases of the delta reflecting its desertification can help extrapolate this trend projecting it for another time span of 8 years into the future. This will lead to a calculation of the forecast vector for the condition of the ecological phases; a shrinkage in the area of hydromorphous and mezomorphous phases and an increase in the area of halomorphous phases by 1986.

This technique makes it possible to arrive at a spatial model for the desertification dynamics and offer its probability forecast, which can be eater updated. The forecast can at a later stage incorporate quantitative corrections due to changing conditions resulting from the emergence of new ecological phases, implementation of land reclamation programs, etc.

In studying desertification at its different hierarchy levels the aerial and space monitoring technique offers quantitative criteria to register desertification processes ranging in magnitude from local to regional; as well as a quantitative probability forecast for desertification at different times and in different areas.

LANDSCAPE APPROACH TO STUDIES
OF DESERTIFICATION PROCESSES

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The current interpretation of the notion of "desertification" is rather wide: more often than not it includes an overall aridization of an area, landscape xerophytization, degradation of the soil and vegetation covers. Authors regard "desertification" as formation of natural and man-induced landscapes of a particular type in the semi-arid zone, which owe their existence to the combined effect of natural and anthropogenic factors. Desertification processes can develop as a result of direct or indirect human pressure on the landscapes. This paper discusses the case study of the Loony River (Rajasthan, India), and analyses the formation of natural and man-made landscapes as a result of agricultural uses of an area, as well as the processes going on in the already formed natural and man-made landscapes. Based on the study of literature available and on direct observations in the Loony Basin, the following conclusions are drawn:

(1) The processes of man-induced desertification in the area are very extensive.

(2) Plant formations (at the type level) existing in the Loony Basin differ from climax formations, corresponding to pre-

sent-day climate due to partial or complete destruction of natural vegetation and to its replacement with cultured vegetation on the cultivated lands; it is also due to the thinning of vegetation, alternation of the dominant life forms, the changing species on the virgin lands.

(3) As a result of desertification under conditions of a semi-arid zone an evolutionary sequence of natural and man-made landscapes is formed, characterized by different degrees of desertification, but at each particular stage similar to the natural landscapes of more arid areas.

(4) In the existing natural and man-made landscapes, mainly due to the changing vegetation cover, water-erosion processes become very active, peculiar to the natural landscapes of the given zone, and new aeolian processes occur, earlier not observed here, the processes of resalinization and other processes, typical of the landscapes of more arid areas.

As the present-day state of the vegetation cover is one of the most important indicators of the extent of desertification development and is an integral indicator of intensity and of the forms of agricultural pressure on the landscape, we distinguish natural/man-made landscapes (similar to natural ones) by the dominant type of the vegetation formation. In the Loony Basin, in the thin forest and shrub zone, natural/anthropogenic deserts have now been formed, along with semi-deserts, savannas, thorn-shrub savannas. Using various parameters, they assess the degree of their adequacy to the original natural (reconstructed) landscapes and to the landscapes of the arid zone having a similar type of plant formations.

By analysing the maps of reconstructed landscapes, of spatial distribution of the soil-geomorphological desertification process-us and of the land-use pattern a landscape map of the Loony Basin, scale 1:1,000,000 was prepared showing the natural/anthropogenic landscapes at different stages of desertification, and the processes forming such landscapes.

PROCESSES OF NATURAL AND MAN-INDUCED DESERTIFICATION OF DRY STEPPE AND SEMI-DESERTS IN KAZAKHSTAN FROM THE PALAEOGRAPHIC POINT OF VIEW

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The dry steppe and semi-desert of Northern and Central Kazakhstan adjacent to the northern boundaries of Turan's desert zone are affected by both natural and man-induced desertification. This trend characterizes not only the present but also the remote pre-historic past.

Though Asian steppe is known for its high palaeographic stability during the Pleistocene and Halocene they repeatedly became the scene of desert landscape expansion usually coincident in time with xerothermal phases. This is supported not only by palaeogeographic data but, above all, by the present-day natural conditions prevailing in the dry steppe and semi-desert, in which many traces of past desertification have survived. They include desert relief forms and the corresponding porous sedimentation, soil cover structures typical of arid-denudation-lithogenous alkali-desert-steppe areas, relicts of flora and fauna. One can mention a number of present-day landscapes of the steppe and semi-desert zone, which were formed under the impact of the pre-historic desertification process. These include, for example, sand-aeolian desert steppe and deserts, desert-steppe arid-denudational plateaus and smoothed small-dune landscape, desert arid-denudation chink slopes and their piedmonts.

Apart from desertification in automorphous positions related to recurrent climate aridization, dry steppe and semi-deserts are not characterized by hydromorphous desertification. It occurs under normal zonal climatic conditions and is even intensified by an increase in soil moisture. Hydromorphous desertification affects low terraces and the bottoms of pre-historic and present-day river valleys, lake bowls. Under insufficient drainage conditions and with a high saline water table they become a site of hydromorphous salinization. As a result desertified natural complexes emerge that can be described as valley and lake-bowl saline and alkaline and solonets-desert-steppe.

An analysis of the present-day landscape structure of the region shows that in dry steppe automorphous desertified landscapes account for 17-18% of the zone area, a similar figure covers hydromorphous desertification. In the semi-desert zone they begin to play a more important role, and the ratio changes in favour of the former: 32% and 21% respectively.

At present, under the conditions of atmospheric moisturization normal for the steppe conditions, and the predominant neotectonic land elevation accompanied by better drainage, the dry-steppe zone shows a trend towards a natural steppezation of residually desertified natural complexes. Inversely, in semi-desert conditions they are quite stable, sometimes progressing.

Man-induced desertification in Kazakhstan has long been a result of rangeland deterioration. Among the large number of steppe and semi-desert natural complexes the most vulnerable to rangeland desertification were the ones that have inherent traces of desertification both past and present. The process is intensified by combination of natural and man-induced desertification. This can lead us to a classification of dry steppe and semi-desert landscapes in Kazakhstan in terms of their possible vulnerability to desertification, to the understanding of optimal grazing patterns and to programs of environmental protection.

ROLE OF GEOLOGICAL AND GEOMORPHOLOGICAL FACTORS IN DESERTIFICATION

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The typical deserts as a climatic phenomenon feature, in their genesis, a number of landscape characteristics preconditioned by aridity. However, the general exsiccation of a landscape and the development of typically desert traits may be a result of many physico-geographic processes going on outside the arid zone. These include physical and chemical weathering, destroying the rocks and contributing to their removal from the surface; soil erosion accompanied by the destruction of the sod cover and a decrease of soil productivity; formation of erosion furrows with subsequent deflation of the soil material; the development of karst processes leading to the lowering of the water table; landslides and debris avalanches, clearing the slopes, etc.

Desertification processes can be stimulated by the specific geological (lithological) conditions. Thus, sand material of the areas on the verge of aridity are subjected to deflation easier than other types of soil, producing the forms of aeolian relief characteristic of deserts (Central Fergana, Kzylcha Synclinal

Fold of the Gissar System, Char Kettle Depression in the central section of Baikal-Amur Railway Line, otherwise referred to as "Char Kyzylkums"). The dark colouring of the material encourages its heating, a local increase of temperature, and, as a consequence, fast snow-melting, reduced air humidity and evaporation (e.g. Baisun Kettle Depression, Mogoltau). The development of salt-bearing material rapidly transfers the area to the category of desert lands with characteristic salinity of groundwater, alkalinity of soils thin vegetation (e.g. Veeliyoui Lowland in the taiga zone).

The above-named desert landscapes emerged when the climate was not arid. Thus, the main cause of desertification is the dryness of the surface and of the landscape, and not just aridity (lack of precipitation, high temperatures, heavy evaporation and other signs of aridity). The reverse also happens, when non-desert landscapes emerge in the deserts, e.g. tugai.

The rate of desertification is fastest where climatic conditions are arid or bordering on arid, where desertification phenomena occur even with relatively insignificant disturbances within an established natural habitat. It is in this type of a situation that the responsibility of man, inducing the changes in the landscape links, is particularly great.

Therefore, all economic activities and special desertification control measures should be planned on the basis of hydrological, climatic, lithological and geomorphological factors, with due regard for the exogenous relief-formation processes which may result in the formation of desert landscapes.

HEAT BALANCE AND IMPROVEMENT OF LANDSCAPE-CLIMATIC CONDITIONS OF ARID AND SEMI-ARID ZONES IN THE AZERBAIJAN SSR

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Five out of ten established zones featuring different moisture conditions in the Azerbaijan SSR are grouped as arid (extremely arid, highly arid, moderately arid, arid, slightly arid). Arid zones account for about 60% of the Republic's area, encompassing all lowlands and adjoining sections of submontane areas and low-mountain stretches of the Grand Caucasus, the Smaller Caucasus and Talysh; in the Nakhichevan Autonomous Republic these zones are elevated as high as 1,500 m above sea level. The vast area with a semi-desert and dry-steppe climate has a heat balance index ($\frac{LE}{R}$ x 100) of 20-35%. This means that 65 to 80% of the annual radiation balance is consumed by the turbulent heat flow released to the atmosphere with only 20 to 35% lost as evaporation (in the summer season, 70-90% and 10-30%, respectively).

The arid zones and the adjoining submontane areas are subject to desertification processes: Kura tugai forest areas decline sharply; the same applies to the forest areas of the northern part of the Samur-Divichinsky Lowland, to submontane juniper forests, to the grassland-forest strip in the northern and central parts of the Alazan-Agrichaisky Valley. Sheet erosion and ravine formation processes become more intensified in the submontane areas of the Grand and Smaller Caucasus. Soil salinity is a growing concern in areas of well-established irrigated farming. Sand and sand dune areas are expanding along the Caspian coast.

Analysis of precipitation and cloud coverage observation data for the last 90-100 years indicates no growth of aridity in the climatic conditions of arid and semi-arid zones and the adjoining areas. Thus, the basic cause of the current desertification process is human activity. The only exception is the circum-Caspian area, where desertification is due to the fact that the Caspian Sea level has for the past 50 years (1929-1978) gone down by 3 m. Desertification is accompanied by the changing pattern of heat balance and landscape transformation in the arid and semi-arid zones.

Active measures are needed to combat desertification. These should include irrigation and afforestation with drought-resistant tree species. There must be also strict observance of irrigation rates, stocking rates and forest cutting rates. Land use practices to prevent erosion, etc. should be applied.

AGROCLIMATIC RESOURCES OF DRY LANDS OF THE AZERBAIJAN SSR AND WAYS OF THEIR RATIONAL UTILIZATION

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A considerable part of the Republic's agricultural production is concentrated in the arid zone, which accounts for over 60% of its territory, soil-moisture being insufficient and sometimes very low. This notwithstanding, this territory has considerable heliothermal resources. Estimates indicate that, given adequate irrigation, some areas of the Kura-Araks Lowland may show higher values of the bioclimatic potential (4.6) than the temperate-to-humid Lenkoran-Astara agro-climatic area (4.4). This potential, with irrigation, can be used for the cultivation of valuable subtropical crops (pomegranate, olives, persimmon) getting 2 or 3 harvests a year.

The authors suggest a method for quantifying the indices of disproportion between the heat and moisture, which enables them to solve a number of practical issues, including the establishment of the irrigation rate. They also analyse the interaction of forest and climate, illustrating the likely climatic changes resulting from the transformation of the underlying surface, in particular, of alpine forests. Based on the analysis of the data obtained in several mountain systems of the subtropical zone, a conclusion is drawn to the effect that further impoverishment of forests in the mountains not only contributes to intensifying the aridity of climate, but also leads to the over-cooling of slopes in winter, reduction of the minimum air temperatures, and consequently, to the degradation of ecological conditions of subtropical vegetation in plain and submontane areas.

In the arid areas of the Republic, not only land reclamation, but also climate improvement measures are necessary. More rational utilization of climatic resource of the arid zone of the Azerbaijan SSR calls for strict observance of the formula "irrigation + subsurface drainage + field protection afforestation + advanced farming practices".

SOIL EROSION AS A FACTOR OF DESERTIFICATION

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It is well known that overgrazing results in the digression of vegetation. However, the ultimate results of digression are, to a large extent, determined by the humidity pattern. In the humid areas grazing brings about change in species composition of vegetation. Such important soil protecting factor as density shows no significant changes. Under conditions of insufficient moisture digression is followed by a rapid decrease in vegetation density.

This decrease results in the reduction of rainfall infiltration into the soil since a thick low-permeable crust is formed on the soil surface unprotected by vegetation under the action of raindrops. Reduction of permeability leads to an increase in slope runoff coefficient which accelerates erosion. Therefore, in spite of scanty rainfall, intensity of soil losses on the slopes with rarefied vegetation reaches a value of dozens and hundreds of tons per year from one hectare.

The wash of humus-accumulating layers and exposure of dense low-permeable illuvial layers result in further reduction of permeability (up to a level of mm/min^{-3}) and a corresponding increase in surface runoff, especially if the surface is composed of the carbonate crusts or saltbearing soil.

The mentioned succession of processes causes aridization of landscapes, extreme cases of which can be illustrated by secondary badland-type landscapes of SE Daghestan, intermountain depressions of Central and Western Caucasus, Southern Uzbekistan and Turkmenia.

Aridization of separate regions, in turn, is the reason for redistribution of human pressure on landscape and thus the whole process reiterates involving new areas.

These undesirable phenomena could be prevented by the introduction of regulated grazing and a sound land use policy during the initial phase of the process. Intensive erosion development demands expensive reclamative measures including chemical and mechanical stabilizers along with grass plantation and temporary prohibition of grazing. Reclamation of areas with bare carbonate crusts or saline soils is technically unfeasible and economically unsound in some cases.

THE ROLE OF SOIL INVESTIGATIONS AND LAND MANAGEMENT IN COMBATING DESERTIFICATION

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Central Asia is characterized by specific natural conditions. The greater part of its area is occupied by deserts and semideserts with extremely fragile soils affected by insignificant change in the climatic and other natural factors as well as by unwise human impact.

The mountain and piedmont areas with marked slopes and storm-like pattern of rainfall suffer from severe water erosion, especially on the slopes of solar exposition. Soil degradation is aggravated here by deforestation, overgrazing and in places unwise rainfed farming practices. In the desert (plain) zone soil degradation is caused by wind erosion (deflation) and salinization.

Soil science plays an important role in determination of cases of land degradation (desertification). Current methodology of soil investigations enables detailed assessment of the level of soil degradation and productivity loss. Here, repeated soil survey data serve as the major component of monitoring. These data reflect change in desertification degree of arid and semi-arid areas better than any other indices. It is important that the soil survey data represent not only the degree of soil degradation but also the potential danger of further desertification. Factors reflecting the degree of potential hazard bear a zonal character. In the mountain and piedmont semideserts these are - slope gradient and exposition, depth of the fine-earth layer, soil genesis. In the desert zone - lithology, depth of the loose water bearing layer, salt contents, depth and salinity of groundwater and some other factors dependent on specific natural and agricultural conditions.

The soil survey data provide with main parameters for elaboration of the scientifically-based projects and measures of soil degradation control, they help to define strategies for rational use of each land plot.

Among measures of desertification control important are those elaborated and introduced by the land use planners. They include: organization and management, agrotechnology, reclamative afforestation and hydraulic engineering.

Proper land use planning is a significant item in the system of desertification control measures. Sound erosion control management of the area, for example, includes all kinds of measures preventing and reducing the erosion hazard on lands susceptible to erosion (slopes, sandy loams and sandy soils). This is a complicated scheme regulating proper distribution of settlements, roads, canals, drainage network, power supply lines, antierosion agrotechnology, crop rotations, forest belts, strict regulation of grazing on rangelands, range rotation, rangeland improvement, range protecting forest belts, provision of gas and electricity for population aimed at reduction of shrub cutting for fuel, etc. Land management also includes the inventory and rehabilitation of degraded lands.

Irrigation in desert and semi-desert zones under proper land use policy improves soil properties and enhances their productivity considerably thus acting as a desertification control factor. Soil investigations in Central Asia as well as the analysis of archeological data revealed that irrigated soils contain more humus and nutrients than any other desert soil.

In virgin lands and ancient fallow lands abandoned in the period of early medieval epoch (X-XI centuries A.D.) humus content is 2-2.5 times less than in irrigated soils; in the younger fallow lands (XVIII-XIX centuries A.D.) - 1.5-2 times.

Fertility of irrigated soils in the semi-desert zone is 4-5 times higher than of rainfed and 12-14 times higher than of desert rangeland soils. Considering high efficiency of irrigation as a factor of fertility improvement and desertification control, republics of Central Asia implement intensive irrigated development of deserts.

There have been elaborated forecasts of the development of new lands for a long-term prospect. Soil survey data served as a basis for land quality assessment and elaboration of reclamation measures. At present due to full utilization of the Amu-Darya and Syr-Darya rivers supply for irrigation a problem of partial Siberian rivers flow transfer to the desert zone of Central Asia is under way. Implementation of these plans enables to increase soil fertility of the arid zone and to decrease the process of soil degradation.

COMPREHENSIVE DEVELOPMENT OF THE KARAKUM DESERT'S MINERAL RESOURCES

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Expertise collected in the course of the Karakum desert industrial development represents a certain measure of scientific and practical interest in terms of comprehensive development of the desert's mineral resources. The territory of the Turkmen Soviet Socialist Republic possessed deposits of pure sulphur (Garvaza, Gaurdak and others), coal (Bolshoi Balkhan, Ugitang, Tuarkyr), zinc and lead (Kopetdag, Kugitang), cinnabar (Kopetdag), mineral water springs (Kopetdag piedmont), bentonite (Oglanly, Kopetdag), sodium chloride (Gaurdak, Karkyuk, Duzgyr, Karabogaz, Kurtysh and others). The deposits of these minerals can be found in the Karakum desert and mountain areas adjacent to it. The following large industrial areas can be identified:

1) West Turkmen industrial complex is characterized by highly developed oil and gas industry. There are 22 known deposits of the two minerals connected by oil and gas pipe lines, excellent highway communications and high voltage electric lines, which creates favourable conditions for continued intensive development of oil and gas extraction and chemical processing.

2) East Turkmen industrial complex consisting of two industrial areas: Murgab and Amu-Darya. The Murgab area specializes in gas extraction, gas and chemical industry to produce N-fertilizers and carbamide. The Amu-Darya industrial area where gas is extracted from gas condensate deposits and plans are made to extract from gases their heavy fractions and condensate to set up a gas and chemical complex to produce N-fertilizers, carbomide, synthetic materials such as rubber, polyethylene fibers, etc. using the oil processing facility in Chardzhou. Plans are also made to produce gaseous sulphur as a by-product (from sulphur gases which are only 10 to 13% the cost of sulphur in Gaurdak, whose development is also included in the plans.

3) Central Turkmen industrial complex is characterized by high probability of oil and gas extraction from the Kopetdag strip from the depth of 7-10 km.

The comprehensive development of the Karakum desert's mineral resources in the waterless desert has given birth to the industrial cities of Nebitdag, Gazachuk, Kaurdak, Cheleken, Neftezavodsk. What used to be the small towns of Mary and Chardzhou have become large industrial centers. Hundreds of well-appointed green oases have sprung up, such as Kumdag, Velyak, Vyshka, Uchtepesh, Atlyk and others.

ECONOMIC EVALUATION OF MINERAL AND
RAW MATERIAL RESOURCES OF THE DESERT
ZONE OF SOVIET CENTRAL ASIA

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In assessing the efficiency of judicious utilization of mineral resources in the desert zone it is necessary to take into consideration that an integrated approach to the problem will increase the economic effectiveness of the final social product, a phenomenon accompanied by a drop in the cost of production and application of its individual elements, transportation costs go down, work effectiveness increases and accumulation builds up. All costs in an integrated production should be distributed in proportion to all types of individual products at each of the processing stages irrespective of whether they are end-products or intermediate ones.

We propose a number of empirical formulae to determine the economic effect of integrated utilization of the mineral raw materials in the region's desert zone where losses in a particular component are factored in. The absolute economic effect of integrated utilization of raw materials (E_f) can be found from the following formula:

$$E_f = \frac{(z'' - z') + \Delta E}{K_{total}}$$

where z' and z" represent the operational costs before and after programs for integrated raw material utilization.

K_{total} is total capital investment into fixed assets necessary to implement integrated raw material utilization (in roubles).

ΔE is the economic effect from integrated mineral raw materials utilization.

The overall economic effect from the integrated raw material utilization will be a simple sum of the indicators for economic effect in the production of each useful component, i.e.

$$E_f = \sum_{i=1} \frac{z''_i - z'_i + Y\ iQi}{K_i}$$

2-2

An important component in the economic evaluation of mineral resources in the planning of regional development of Soviet Central Asia's desert zone is the calculation of economic losses from injudicious use of mineral resources, more particularly their negative impact on the environment. These losses primarily consist of losses of valuable raw materials to industrial waste (L(w));industry (L(i)-early wear and tear of equipment, corrosion time losses, etc.);in agriculture (the use of land, the drop in productivity, etc.) (L(a));municipal losses (additional expenditure on cleaning operations, repair of buildings, etc.) (L(m));in water economy (pollution of water resources) (L_{we}) and deterioration in public health. ($L_{p.h.}$)

$$L_{total} = L_{(w)} + L_{(i)} + L_{(a)} + L_{(m)} + L_{(w.e.)} + L_{(p.h.)}$$

ECOLOGICAL FORECAST OF DESERTIFICATION PROCESSES IN TOURAN REGION

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Natural, historic and man-induced factors, under the influence of which the environment conditions of Touran Region was formed, determine the presence of ten provinces of Iran-Touran Region, different in genesis, age, ecological climate, soil-salt and vegetation composition.

The trend of the arid biotocoenogenesis had a definite adjustment quality and was accompanied by the loss and adaptive reorganization of the subtropical elements, partially replaced by elements of Touran flora, by xerophytization, psamophytization, ephemerization. The formation of the flora littoral elements was also very important.

The existing ecosystems of Touran Region comprise 8 classes based on the characteristics of vegetation, soils, bioproductivity (and pedophytogenesis). These (and especially vegetation) were subject to dramatic changes as a result of human activity: (1) regulation of river flow and withdrawal of lands for irrigation, later to be abandoned (post-irrigation alterations, drainage of flood plains); (2) cutting of desert forests; (3) use of vegetation for cattle grazing; (4) technological impact and related development of road network. Ecological situation has been mapped: local foci of desertification are marked as well as the ecosystems, heavily, moderately and slightly prone to desertification (judging by the characteristics of ecoclimate, edaphic medium and vegetation).

Among the established types of desertification, the most common are exsiccation and wind erosion, heavy secondary salinization, overgrazing, formation of badland and barrens.

We have prepared the ecological forecast of desertification taking into account the existing land-use system and the growing tendency to intensify irrigation and animal husbandry by 25% and more. The criteria used in making the ecological forecast are: upsetting the pattern of vegetation, its being wholesome and self-regulating; decrease of productivity and underutilization of the environment resources; disturbance of ecological links and discrepancy between the unstable modifications of vegetation and the environment; non-optimal structural changes in the water-salt regime of the soils and in their texture by biogeohorizons. Scales of rangeland degradation are now being devised.

Among the consequences of the established ecological shifts in the degrading rangeland ecosystems are reduced photosynthetic activity and diminution of the photosynthetic layer in the biocoenoses of deserts.

For mapping the degressions (potential foci of desertification), it is suggested that maps of land-use intensity be prepared first.

EVALUATION FORECAST OF POSSIBLE ADVERSE WIND EROSION PROCESSES IN THE DESERT ZONE OF SOVIET CENTRAL ASIA

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The research program undertaken in 1954-1969 in the sands of Central Ferghana determined that the annual sand transport can be found from the formula (Danilin A.L., 1969):

$$Q = K\left(\sum U_f^3 - \sum U^3_{tf}\right)$$

Sand removal, or the removal of sandy soil from 1 ha at the length of the test-strip of 1000 m - Q = 10K with the strip length = 500 m - $Q = 20K(\sum U_f^3 - \sum U_{tf}^3)$. The average blow-out depth will be respectively

$$h = \frac{10\,K\,(\sum U_f{}^3 - \sum U^3{}_{tf})}{10000}\ ;\quad h_{з} = \frac{20K(\sum U^3{}_f - \sum U^3{}_{tf})}{10000}$$

where Q is the annual transport in M^3 or removal from 1 ha in m^3 per year,

h - is the average blow-out depth in cm,

K - is the angle coefficient,

ΣU^3_f is the sum of cubic velocities at the wane height per year,

ΣU^3_{tf} the sum of threshold velocities elevated to power 3 at the wane height per year.

The result of the calculations covering 34 points in Central Asia are summarized in the Table. Further on is the regional division of the territory of Soviet Central Asia in terms of intensity of wind erosion hazard, based upon the data of the table (the blow-out depth at the test-strip length of 100 m).

1. Regions with a moderately active wind regime (the blow-out depth ranging from 0 to 2 cm per year): Karshi - 0.80; Chimbai - 1.20; Gulistan - 1.36; Ferghana - 1.44; Kagan - 1.60; Namangan - 1.86; Turtkul - 2.0; Asht - 1.0; Leninabad - 1.82; water reservoir of the Ferghana hydropower station - 0.69; Shartuz - 0.69; Ashkhabad - 1.0; Iolotan - 1.0; Tashauz - 1.34; Erbent - 1.34; Bakhardok - 1.34; Darganata - 1.34; Gaudan - 1.36; Bakhorden - 1.66.

The moderately active wind regime zone includes 60% of the territory of Central Asia. In areas with a moderately active wind regime it is sufficient to apply the simplest anti-erosion agrotechnology. Irrigation strips can be 600-1000 m long. Wind break strips basically perform the function of improving the microclimate rather than of anti-erosion protection. Sand fixation operations may involve the use of mechanical cover and narrow-strip chemical coating.

2. Regions with an active wind regime (blow-out depth - 2-4 cm per year): Mubarek - 2.46; Karakul - 2.70; Urgench - 3.0; Termez - 3.96; Muinak - 4.0; Kazandjik - 2.35; Kerki - 2.35; Kyzyl-Arvat - 2.35; Chardzhou - 2.86; Sarakhs - 2.93; City of Krasnovodsk - 4.0.

The active wind regime zone covers one third of Central Asia. In areas with an active wind regime, at the early stages of land reclamation it is necessary to use anti-erosion agrotechnology and soil-protection land-tilling practices. Irrigation stripe must be reduced to 400-500 meters or strip land tilling should be used, following A.I. Barayev's technique. On irrigated land wind-break forest strips are essential. Care must be taken not to overgraze the rangeland, which might result in soil deflation. Construction work must have wind-erosion factored in.

Sand fixation utilizes strip mechanical protection units, narrow- and wide-strip chemical coatings, on elevated areas-latticed protection devices and continuous chemical coatings should be used.

3. Regions characterized by a very active wind regime, with blow-out depth at 4-6 cm per year; Kokand - 6.80; Jangeldy - 7.60. These regions cover 5-7% of the territory of Central Asia.

Land tilling is impossible without the use of anti-erosion and soil conservation agrotechnology. This particularly applies to row crops. On irrigated tracts wind-break forest strips are imperative, with the distance between strips not exceeding 200-300 m. Rangeland soil deflation in highly probable. Construction operations mu t take into account wind-erosion hazards.

Sand fixation is ensured through strips, lettuce and continuous mechanical covers. Chemical coating can be narrow-strip, wide-strip and continuous.

DESERTIFICATION FORECASTS OF THE NATURAL COMPLEXES OF THE AMUDARYA'S COASTAL DELTA

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Intensive desertification of the lower reaches of the Amudarya related to decreasing level of the Aral Sea increases the importance of a forecast for possible desertification of the region's natural complexes. The forecasting is based upon several factors, such as the drainage impact of the Aral Sea, wind erosion and halogeochemical processes, drops in the ground-water table, its higher salinity, xerophitization of plant communities, soil evolution towards automorphism, aeolian desert terrain formation, and others. This also takes into account the lithological and geomorphological structure and the hydrogeological conditions of the territory, the type of the soil-forming process, prospects for the region's development aimed at irrigated land tilling or rangeland irrigation, as well as the structure and properties of the geosystems.

The western part of the delta, which as present is a hilly solonchak complex, if denied irrigation, would have developed towards progressing salt building in the aeration zone, resulting in a drop in the ground-water table below 3-5 meters from the surface. The dominant role would be assumed by the saltwort - yulgun phytocenosis and salt build-up in the root horizon would lead to karabarak.

Excessive dryness of the upper soil layer, vegetation's decreased projective coverage can result in more intensive wind erosion processes, degradation of kupaks and elimination of the top fertile peaty soil. As groundwater goes down to 10 meters and deeper the solonchaks gradually lose excessive salinity, the salt gets concentrated in the lower soil horizons, which become takyr solonchaks or takyr soils. At the initial stage of solonchak takyrization vegetation becomes mixed. Solonchak patches with karabarak alternated with takyr patches overgrown with karagan or itsegek. Protracted dryness in the soil down to 10-15 meters leads to the dying away of yulgun and karabarak and formation of saxaul and saltwort (Haloxylon-Salsola) group. At that time kupaks are fully eliminated by deflation and on sandy-loam water-sheds deflational and accumulative forms of aeolian landscape overgrown with xerophites will be formed.

Considerable changes are possible in the Aral solonchak complexes, with the groundwater table going down to 5-10 meters or deeper, typical solonchaks lose some of their salinity, a process accompanied by more intensive wind erosion and accumulation. The deflation of puffed-up solonchaks leads to transport of a vast amount of salt and salt dust in the southerly direction, resulting in the formation of hills, dunes and hollow aeolian relief, which leads to a vastly uneven terrain in the surface of the plateau.

In the eastern part of the Amu-Darya delta with automorphous geocomplexes prevailing, these latter will develop towards soil de-salinization and more active aeolian processes. Wind erosion processes are made more intensive not only by the drying of the upper soil layers, but also by more intensive technological erosion and cutting down of trees and shrubs. All this may result in the emergence, at some sections, of the aeolian sand dunes with the respective psammophites.

SOCIO-GEOGRAPHICAL ASPECTS OF PRESENT POPULATION DEVELOPMENT

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Soviet Central Asia, a large region with diverse physiographic conditions, multinational composition of the population, high economic growth rates and an established structure of the economy, offers dissimilar conditions for the reproduction of population and labour resources. Study of these intra-regional distinguishing features has large importance for the national economy and indeed is intimately related with the accomplishment of the objectives set forth by the 26th Congress of the Communist Party of the Soviet Union in respect of the formulation and implementation of an effective demographic policy in our country as a whole and in the Central Asian region in particular.

One of the primary distinctions of demographic development in the Central Asian Soviet Republics has been a fundamental change in the pattern of reproduction of the local population.

As a result of an acute reduction in mortality and especially because of sustained high birth rates among the indigenous nations, there has been a change-over from the reduced to the extended pattern of population reproduction.

The Basic Guidelines for the Economic and Social Development of the USSR for 1981-1985 and for the Period Ending in 1990 reads, "To facilitate the comprehensive development and the drawing closer together of the nations and nationalities of the USSR, the greater social homogeneity of society, and the firmer ideological and political unity of the Soviet people as a new historical entity".

Hence the overriding importance of the rapprochement and fusion of nations for a multinational region such as Central Asia. Speeding up and correctly understanding the process is therefore an essential problem arising out of the region's demographic situations. Dynamics of demographic structures and the structure of employment provides a major tool to control the process, while the increasing social homogeneity of the region's population is its result and proof.

A telltale feature of demographic development in Central Asia is an accelerated rate of urbanization based on steady and consistent industrialization. By now Central Asia has developed into a large industrial and agrarian region of the USSR, with advanced industry and a broad network of cities and urban settlements whose residents account for 40% of the region's total population. Large urban agglomerations representing, in effect, the highest forms of urbanization and cells of a highly urbanized environment were formed in the region.

The present demographic development of Central Asia is and will be exerting a certain influence upon the general demographic situation in the USSR because of the continuing high natural growth rates of the region's population. Whilst presently the Soviet Republics of Central Asia concentrate 10% of the country's population, there will be 15% of the total living here by 1990. This poses a series of complex socio-economic and scientific-technological problems while this serious socio-geographical aspect of population will have to be comprehended in greater depth and dealt with in a purposeful and earnest manner.

OPERATIONAL PROCEDURE TO
FIX SHIFTING SANDS

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In the deserts of Soviet Central Asia shifting sands account for 3-5% of the entire territory. Their formation is generally attributed to aeolian processes resulting from high wind velocity, excessive atmospheric precipitation, scarce vegetation and extensive porous tertiary sedimentation. Factors compounding to increase of the areas occupied by shifting sands usually include extensive forms of economic activity in deserts. In agriculture shifting sands are regarded as areas not possessing any economic capability. Shifting sands not infrequently devour agricultural tracts and land that could be used to site different economic facilities.

Methods to control shifting sands comprise programs including stabilization of sandy surface followed by planting sand fixing vegetation. In Soviet Central Asia stabilization of sandy surface takes the shape of different mechanical devices and application of viscous preparations. The following types of mechanical protection devices are commercially available (Stepanov, 1963): 1) upright mechanical protection devices 0.3-0.7 m high, 2) upright mechanical protection devices up to 20 cm high, 3) cover stripe 60 cm wide, 4) "longitudinal" cover stripe 25-235 cm wide.

Upright devices are installed in the following manner: a groove 20 cm deep is dug along a marker. Protective material is then placed on one side of the groove, put up in an erect position, sand is placed on both sides and compacted. Cover strips are strips of vegetation 5-7 cm thick placed flush with each other. The strips are secured by sand placed in the middle of the strip and weighing it down. "Longitudinal" cover strips are usually made from upright plant material 10-15 cm thick, 25 cm wide. In placing the material down the protection line it is ensured that bunches of stalks overlap and are weighed down with sand at junctions. The protection strips can be fixed in place by cuttings planted in pairs on both sides of the strips at an angle to each other.

Stabilization of sands with viscous substances is ensured by mechanized spraying of the fixing substance either in strips or covering the entire area. Only substances non-toxic to plants are allowed for use, such as nerosine, fuel oil, sulphite waste liquor, resins, polymers, latex, etc. If sand fixation is done in strips the viscous substance is applied whenever vegetation is planted. If the entire area is to be stabilized the preparation is first applied to the windward slope of the dune chain and then on higher portions thereof. Fully mechanized application of viscous materials in sand-fixing operations can be achieved by a system of machinery including a full-track tractor (DT-75 "B") equipped with a sprayer, a "ZIL" truck to haul the viscous materials from the warehouse to the site of the land improvement operations, a bulldozer (DT-75 or C-100) or similar type to lay temporary communications in the sand dunes. Stabilization of shifting sands with viscous substances holds considerable promise for the future. It reduces operational costs by a factor of 4-5 and increases work efficiency by a factor of 30-40.

SUCCESSFUL COMBATING DESERTIFICATION IN KARAKUMS

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The causes of desertification are various. In the Karakums, in addition to climatic changes of global nature, active factors of the desertification process were tectonic movements in the Caspian Sea, which produced changes in its level and surface area; overgrazing of circum-oases lands; cutting of trees in the desert and in the mountains adjoining the desert; redistribution of water resources as a result of irrigation development causing the drying up of Aral deltas and formation of new sand-solonchak expanses in the circum-Aral areas.

In the 1930-1940s, the lowering of the Caspian level by more than 2 m triggered the lowering of the water table all along the coastal strip, reaching 170 kms in width (e.g. the former Cheleken Strait - Aidyn Station, east of Nebit-Dag). Throughout this strip, featuring a wide occurrence of sand solonchaks, the top 0.5-1.0 m thick layer dried up. As a consequence of its deflation, nearly all of the solonchak areas were covered by barchans damaging the communications and making human activity difficult in this region and in the areas close by.

Astrakhan sheep breeding in the Middle Amu-Darya Oasis, overgrazing of the land in the past and the cutting of shrubs led to the formation of the Amu-Darya barchan strip, 5 to 25 km wide, extending from the Afghan border to Dei Nau Village along the left bank of the river. As a result of sand encroachment, the Oasis width in places contracted by 10 km. The barchan barrier separated the Oasis from the desert rangelands.

South of the Khorezm Oasis, as a result of shrub cutting, grazing and surface trampling in the course of cattle driving, a 15-20 km-wide barchan barrier was formed, its tongues reaching far into the south along the caravan routes (as early as in 1955 "Khiva Tongue" was 75 km-long). In West Chi Mamekums, the high quality of cattle watering places brought about the concentration of cattle grazing, which resulted in the formation of a barchan tract, about 150,000 ha in area. The outskirts of the Murghab and Tejen Oases had until 1960s been surrounded by barchan tracts - the aftermath of continued tree-cutting, grazing and trampling for centuries. The Murghab Valley was separated from the desert by 4 km-wide "barriers" of trampled sands. Shrubs were cut in a strip more than 40 km-wide running along the Akhal-Tekin Oasis. In Darwaza-Zeagli area, concentration of population and cattle around industrial settlements as well as sporadic traffic and earth works activated the sands in the radius of 25 km away from these centres. Desert roads designed for rangeland servicing were bumpy, winding and multi-track (in places of intensive traffic the width of the carriage-way reached 1 km). The roads required large areas and were sources of deflation.

Thanks to the studies and use of sand movement regularities, of forest-growing conditions in the areas under consideration, and of new methods of sand control of the last 20-25 years it has become possible to obtain good results. Gasification of settlements put an end to the cutting of shrubs for fuel in all areas of the Karakums. The construction of a few large waterworks in the North-Western and Central Karakums, the improvement of water situation in the 5 mln ha of the Karakum Canal rangelands sinking of new wells deep inside the desert, the full use of modern auto-transport of high trafficability and the use of graders in dirt road rehabilitation made it possible to disperse the cattle and to do away with overgrazing.

There is no large-scale construction project in the Karakums that would be implemented without recommendations of the Institute of Deserts of the Turkmen SSR Academy of Sciences on how to eliminate the deflation side-effects, these recommendations being part of project documentation: the projects can be amended where necessary. Practically there are no sand drifts now on the motor-roads linking Nebit-Dag with Cheleken and Mary with Chardzhou. Previously, the yellow strips of gas-pipelines of the Central Asia-Centre System used to be clearly seen from the space: now they are hardly discernible from a plane. Industrial projects and communications operate in barchan sands continually.

Haloxylon planting from an airplane in the Balkhan corridor eliminated several barchan tracts; barchans and sand drifts, which used to be a common sight in the streets of Nebit-Dag and Kum-Dag in the 1960s, are now a thing of the past. The planting of shrubs eliminated the Jebel barchan tract which used to exist between Yagmai railway station and Nebit-Dag; the sands are now fixed throughout the wide, long strip along the motor-road Jebel-Koturtepe. The use of mechanical protections, of polymer coatings and other binding agents made it possible to protect the pipelines, supports of power-transmission lines and the foundations of works in mines and in oil-fields. Thanks to active afforestation/reclamation measures nothing has been left of the Amu-Darya barchan strip: ornamental Haloxylon is cultivated there now. Small patches of sand, whose combined area is 10% of the original strip, serve as a reminder of what it used to be. Barchan tracts are also eliminated in Western Chil-Mamedkums, west of the Tashauz Oasis, south of Khorezm, in Darwaza Area, along the periphery of the Murghab, Tejen, Kopetdag Oases and around 20 thou ha of barchan fields in the circum-Caspian area.

The Karakum Canal has had an enormous positive effect on the vast desert areas. Landscapes quite different from the desert were formed, plant and animal kingdom were enriched, accessibility of outlying areas was improved. An increase in the better-water supplied areas brought about the growth of rainfall in oases by 12-14%, and as far as 100 km inside the desert - by 7-10%. The areas of the Murghab, Tejen, Kopetdag Oases were expanded considerably, while the Tashauz Oasis advanced to the west dozens of kilometres. Deflation processes registered slackening everywhere except a small site in the former Cheleken Strait.

COMBATING DESERTIFICATION IN SOUTH KYZYLKUMS

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Prior to 1924, in South Kyzylkums, 60 to 70 hectares of irrigated lands were lost to the desert annually. At the time of Bukhara Emirate, desert vegetation (Haloxylon, etc.) was rapaciously cut. Kyzylkum was an area of intensive cattle grazing. As a result, desertification developed on large areas and shifting sands were formed.

After the establishment of Soviet power in Central Asia, planned fixation of shifting sands began in 1925. A strip of arborescent and shrub vegetation was made north of the Bukhara and Karakul Oases, its present length and width being 125 km and

4-5 km, respectively. This strip of forest not only stabilizes shifting sands but also protects the crops of the South Kyzylkum irrigated oases from dry winds.

Following the transfer of part of the Amu-Darya flow via the Amu-Bukhara Canal, the sight of the South Kyzylkum desert lands has drastically changed since 1965. 136,000 ha has been developed for irrigated farming. In Bukhara Region, where all irrigated lands of South Kyzylkum are located, gross production of cotton (unginned) in 1940 was only 132 thou tons, while in 1980 it amounted to 629 thou tons. Malichul lands which had been barren for centuries were transformed into blooming gardens. After commissioning the 2nd and 3rd stages of the Amu-Bukhara Canal in South Kyzylkum, the development of another 600 thou ha of dry lands for irrigation will become a real possibility.

To achieve a more rational management of South Kyzylkum desert lands, systematic anti-deflation measures will be required. These include undersowing desert plants, forming green belts on newly irrigated lands, and construction of a drainage network.

POPULATION DISTRIBUTION, DISTINCTIONS AND URBAN DEVELOPMENT IN ARID ZONES OF SOVIET CENTRAL ASIA

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Natural environment has an immediate impact on the distinctions in the formation of regional systems of human settlements and urban development, the emergence of forms and divergent territorial habitation structures, which to a considerable degree determines the fundamental trends and ways to solve the various socio-economic problems under specific natural and geographic conditions. In that context a lot of interest is aroused by research into the distinctive features behind the formation of habitation patterns and urban development in the arid zones of Soviet Central Asia, where considerable expertise has been accumulated of solving socio-economic problems on the basis of integrated development and mission-oriented approach.

In accordance with intra-regional differences in the overall natural and geographic situation in Soviet Central Asia three basic habitation and urban development types can be identified: oasis, desert and mountainous. The arid habitation type can be found only in a small portion of the region. Its basic distinctions include low population density, high population density in cities, preponderance of cities with high specialized resource profile, a relatively higher index of urban development and territorial mobility among the population. These are related to the distinctive features of development, specialization and territorial organization of production forces in the arid areas, the absence of labour-intensive types of agricultural production based upon irrigated land cultivation.

A large number of typical small-and medium-sized cities based upon particular resources and developing, as a rule, without an agricultural suburb ("cities without suburbs") suggests their relatively insignificant region-forming or urbanizing role. Therefore the actual level of urban development here is lower than in the oasis habitation zone. Urban population does not maintain close contacts with rural population in the same zone. In these conditions the formation of large inhabited clusters including urban conglomerates is difficult. In arid zones they may emerge only as a result of high territorial concentration of natural resources and their complementary combinations.

The above distinctions behind the formation of population and urban development in the arid zones of Soviet Central Asia should be taken into account in mapping out the basic guidelines for their integrated development, especially for building up territorial infrastructures.

PROBLEMS OF URBAN DEVELOPMENT IN UZBEKISTAN AS THE ORGANIZING LINK OF THE REGIONAL SYSTEM OF SETTLEMENT

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Intensive land development in the arid zone, a process specific to Uzbekistan, is attended by transformation of the settlement system. Urban-type settlements are multiplying apace: the number of cities has more than tripled over the past two decades, to reach 104 in 1981. The quantity of urban settlements remains more or less level.

The absolute quantity of urban population has increased 2.4 times over the same time period. To be specially noted in this context is a characteristic feature of Uzbekistan it has in common with the other Soviet Republics of Central Asia - that the fast growth of the urban population proceeds in parallel with the high expansion rates of the population numbers in general, not least of the rural population, whereas in the USSR as a whole the rural population is decreasing and the urban population increasing in absolute quantity.

Reviewing those figures and bearing it in mind that the process of urbanization is dialectically pre-determined and undoubtedly progressive, one can go on to try and understand the role of cities in the specific natural-economic and demographic conditions in which the national economy of the Uzbek SSR has to develop.

The Republic of Uzbekistan's cities may be classified into:

- old cities established in history;

- earlier developed industrial centres possessing a large production and resource potential;

- tho e emergent on the basis of the urban settlements and rural population centres which have overgrown into that rank;

- new cities appearing for the most part in the regions of new development. Among those latter cities, a clear-cut distinction can be made between those brought into existence by mining development and later supplemented with large heavy-industry operations and those located in the regions of agricultural development.

Over 80% of the Uzbek cities have a population above 50 thousand. The sheer fact of these cities outnumbering by far any other category, generates compelling interest towards them and a closer look at the varied and many factors that influence the tendencies conducive to their emergence, and the development of the city-forming phase and the infrastructure leads one to realise their relative importance in the further shaping-out and improvement of the republic's territorial socio-economic structure.

The task of levelling out the economic and social development levels of Uzbekistan's natural-economic regions and areas and the diversification of the componental structure of relatively underdeveloped or newly-developed regions imposes rather stringent demands on the formation of the supporting frame for territorial management of production and population, i.e. the system of cities. In the arid regions "cities" refers overwhelmingly to small towns, at least in the foreseeable future and for the conditions of Uzbekistan where these smaller cities seem destined to be the ones playing the role of effective organizing centres in the settlement system.

Questions pertaining to the development of any city should obviously be considered in terms of maximizing its contribution to the solution of the general problems of integrated regions development and the formation of a single unifying settlement system. This becomes even more relevant in the development and further progress of the regions whose features include specific natural and demographic conditions and ethnic distinctions not infrequently associated with the traditional handicraft occupations and in many cases with the presence of precious monuments of material culture.

URBANIZATION AND WAYS TO PREVENT DESERTIFICATION IN TURKMENIA

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Turkmenia has 15 cities and 74 urban settlements with a summary population of about 1.4 million, or over 48% of Turkmenia's total. Geographically, the Republic of Turkmenia's territorial-urbanistic structure offers a contrasting picture and the allocation of cities among deserts and oases is non-uniform. There is a clearly defined development level of the urban network in oases (Murgab, Mid- and Lower Amu-Darya, and Copet-Dag foothill) and the West-Turkmenian region, on the one hand, and another level observed all over the vast desert area with a sparse network of urban settlements, on the other hand. It should be noted that five out of these towns and 24 out of the seventy-four urban settlements are found outside the oases and surrounded directly by the desert territory. Such an urbanistic situation is, to some extent, a reflection of the long-established territorial and sectoral structure of the national economy in Turkmenia.

The rise and formation of urban settlements in Turkmenia stems chiefly from the development of basic industries - petroleum and gas production, chemistry, and construction - and the augmentation of the administrative, economic and cultural functions of local centers.

Another essential factor in the appearance of new urban settlements in Turkmenia resides in the economic, social and cultural changes subsequent to the construction of the Karakum Canal and new land and mineral development projects in the Canal zone.

Urban settlements in the desert zone are different from oases by the specific pattern of allocation, development rates and conditions for provision of public services and utilities. The settlements out in the desert have not the agricultural environment common for the oasis settlements. There are extensive stretches of the desert lying between towns, settlements and large population centers. The settlements development is determined by the size of natural resource deposits and the scope and sequence of their development. In some cases, these are small-size settlements of the urban-type or workers' settlements like e.g. Darvaz or Yaskhan; in others they include larger urban-type settlements attached to unique mining development areas e.g. Gyardyk, Shatlyk or Bekdash; in still others there are fast-growing towns or urban-type settlements whose functions become increasingly complex, as in Nebit-Dag, Cheleken and Gas-Achok.

TOWNS IN THE ARID ZONE OF THE AZERBAIJAN SOVIET SOCIALIST REPUBLIC

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Nearly one half of the area of the Azerbaijan SSR is found in the arid zone. It concentrates within its bounds three-fourths of the urban settlements and 89% of the population, both suggesting a comparatively high degree of urbanization in the arid zone.

Almost all of the towns located in Azerbaijan's arid zone, with the exception of Baku and Kirovabad, emerged over the last half-century. Active measures to provide the economy and population with irrigation and drinking water, together with the expansion of the production, transport and social infrastructure, laid the groundwork for economic development of the arid zone and the growth of urban settlements. With the development of oil, gas, energy and water resources, industry, the primary city-forming factor, began progressing rapidly. Here the Baku urban agglomeration, one of this country's largest, has formed and several larger centers appeared, such as Ali-Bairamly, Evlakh, Mingechaur, Neftechala, Salyany and Spazan. Not only do they play a major role in the region's economic development but have the effect of altering the appearance of the arid zone.

Urbanization can be referred-to as a factor in the prevention of desertification. The principal nucleus of urbanization in Azerbaijan resides in the Apsheron peninsula, all of which is presently taken up by the Baku agglomeration and possesses a cultivated landscape.

In place of the former desert there exist now industrial, building and transport facilities, living blocks, cultural and welfare and public services, and extensive green plantings (in addition to intra-city plantings, a special green belt over 5,000 ha in area has been established). Formerly semidesertic, Apsheron has become a densely populated and green area. The effect of urbanization on the prevention of desertification is rather significant also in the remainder of the republic's arid zone.

Provision of favourable conditions of work, domestic life and recreation for the population in the arid zone calls for additional investments and increases the costs of urban construction and maintenance of the urban economy. The major part of the costs goes to water supply, greenery plantings, air conditioning and provision of sun-protection screens for the buildings. The water-supply problem is especially acute in the area of Great Baku. There water is brought from a distance of 150-180 km and is several times as expensive as in the cities located on rivers. Under these conditions the agglomeration effect aids in reducing the development costs of arid spaces.

The goals of sustaining the processes of vital activity in the arid zone of Azerbaijan requires lands to be reclaimed and the area's microclimate improved. In the hot season when the street pavements and walls of houses are burning hot under the effect of solar radiation, the air grows stagnant and the environmental conditions begin to cause discomfort. It is therefore required that measures be undertaken to establish green shelterbelts around urban settlements, raise green plantings in residential areas, expand forest shelterbelts along rivers and canals, and improve the structure of populated areas. The experience accumulated over the years in the Soviet Republic of Azerbaijan points to the advantages of integrated urban planning in contributing to the provision of favourable conditions of life in cities while preventing, at the same time, the process of desertification in the Republic of Azerbaijan's arid zone.

CURRENT DEMOGRAPHIC SITUATION AND PECULIARITIES OF URBANIZATION IN THE KARSHI STEPPE

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The Karshi Steppe is one of the new and promising areas in the arid zone of Central Asia. Therefore, a study of peculiarities of the demographic processes and urbanization in this part of Uzbekistan's territory is of great scientific and practical importance.

Intensive development of virgin lands, resulting in the booming agriculture, is accompanied here by the rapid growth of population, especially in the cities. From 1959 to 1980, the population of the Karshi Steppe increased 2.7-fold compared with 1.9 for the Republic as a whole.

During the years of the Karshi Steppe development, migratory tendencies of its population strengthened, both external and intra-regional, which has had an impact on the demography of the territory.

There is a marked predominance of men in the new areas of the Karshi Steppe, which obviously is due to the great need in "manly" skills at the early stages of steppe development. Judging by the age-groups of the Karshi Steppe population, there is a relatively high proportion of able-bodied people and a low percentage of children and pensioners.

A characteristic feature is ethnic diversity typical of new areas unlike the areas of previous irrigation whose ethnic composition is more homogeneous and is mainly represented by indigenous nationalities.

The high birthrate preconditions the dominance of large families, consisting of several married couples.

These peculiarities of the demographic situation constitute, in a way, a reflection of migration processes, stemming from the evelopment of newly irrigated virgin lands, with new cities emerging "from scratch" and as a result of administrative reforms in large villages of advantageous economic and geographical position, which become the basic centres in the territorial arrangement of productive forces.

During the 1970s, 4 towns and 2 township settlements were formed in the Karshi Steppe. The population of Karshi City, the centre of development activities, has increased 3.3 times for the last 20 years and now equals 115,000. The formation and development of the town network occurs as part of the process of territorial distribution of productive forces: setting up basic (town-building) industries (above all, construction industry) as well as in the course of agricultural infrastructure establishment (large irrigation works). A further stage of town formation coincides with the period of intensive development and territorial arrangement of agricultural production.

PROBLEMS OF RAINFED AND IRRIGATED FARMING AND RANGELAND MANAGEMENT

THE PROBLEM OF NOMADS SETTLEMENT IN CONNECTION WITH THE DEPLETION OF THE RESOURCE BASE OF NOMADIC ECONOMY

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The economic rationale of nomadism in the countries of the Orient lies, first and foremost, in the utilization of arid rangelands which otherwise would have stayed outside the scope of productive application. The nomads derive from these lands, which have low value from the viewpoint of traditional sedentary production, a variety of livestock and other products which they bring in part to the marketplaces in towns and villages. In the historical and geographical literature of the past nomads were not infrequently described as a force opposed to the settled population and indeed hostile to it. Studies of Soviet scientists showed the concept to be invalid, as there had been economic links between the nomads and settled residents, brought about by social territorial division of labour.

The historical process is operating nowadays, too, but not in favour of the nomads, leading them to give up gradually their former economic and social grounds. The boundary between the zones of pastoral and agricultural economies has at all times been a volatile one, giving a reflection of the systematic pulsations and the relative mutual might of the interacting parties. Not so nowadays when the nomads are having to retreat under the onslaught of the ever expanding settled population which spreads itself onto the areas where farming culture had been formerly suppressed by the range-based livestock economy. The situation that arises pre-determines conservatism of the nomadic economy, known to be poorly amenable to modernization and thereby becoming much of a hindrance to the development of productive forces. Extensive livestock husbandry shows an uncommonly low production output per unit area, therefore its substitution by agriculture enhances appreciably the demographic "capacity" of an area. Faced with the rapid population growth in the newly emerged countries, official policies cannot but seek to encourage the intensive forms of land resource management.

Further expansion of irrigation in arid regions and mass-scale development of dryland areas through the application of tractors resulted in several countries in a notable reduction of the grazing land areas, as e.g. by 13 million ha, or 30% of the total in Turkey over the post-war three decades. Plowing up a part of grazing lands brings not infrequently more severe consequencies for the stockmen than statistics can ever reflect, for it may well be that a particular seasonal type of range becomes predominantly involved into land tilling with the result that other types of range will be devalued or overgrazed and the stock trails blocked out. Following the increasing stocking pressure upon the remaining pastoral lands, the historically lengthy but gradual process of the deterioration of nature in the arid regions that has occurred under the influence of many-century livestock grazing, as well as hunting and wood cutting for fuel by the nomads, begins to exhibit typically a qualitatively new speed and momentum. The man-environment interaction, already frail and not infrequently upset at the period of unavoidable droughts, has no longer enough time to recover, thus posing a threat to the very viability of the nomadic economy in its traditional forms.

There has been an acute reduction not only of the areal scope but also the economic basis of the nomadic economy. In the past the nomads resorted broadly to additional occupations, such as transporting cargoes, guarding caravans, gathering medicinal herbs for sale to oasis residents, and producing items of handicrafts, since the scarce natural resources available in the arid regions were too short to afford sustained livelihood.

The recent economic trends determined a reduction in the former trade exchanges between the nomads and sedentary population. With improved communication and supply lines, the effective range of urban merchants who would force nomads out, kept expanding. When motor transport appeared on the scene, there followed a decay of caravan trade, while the consolidation of centralized authority forced the nomads to abandon their raids on agricultural oases and the practice of levying tribute from the settled population.

In the situation that arose, promoting the change-over by nomads to sedentary existence constitutes a deliberate way of stimulating an already clear-cut phenomenon. Economic development in the countries of the East through the launching of petroleum industries, transport construction, and hydro-engineering projects forms supplementary labour markets and causes partial outflow of nomads to towns and workers' settlements. This natural process could be accelerated by special-purpose programmes, above all irrigation development and initiation of well-planned settlements near the newly-irrigated lands.

This way of the nomads' conversion to sedentary existence has been tested in some countries of Arab Africa and the Middle East.

Further probability of its wide-scale application depends a great deal on the quantitative correlation of the nomads and settled population in a particular country, the latter's land and water resources and, last but not least, on the financial capabilities and social thrust of the official policies there.

The poorest nomads are particularly keen to settle down. Having experienced bitterly the effects of the reduction in the overall stock of grazing lands, they retained little livestock and lost the motivation to migrate. If such nomads still do migrate, it is not in search of a range but rather looking for jobs in oases, usually during the harvesting season. They need the state to offer them assistance as they change over to sedentation; otherwise they will hardly be able to utilize the land allotted to them. In the areas of new irrigation a complex development problem that arises commonly, more so in the first and in many ways decisive stage, is one of combining traditional livestock husbandry with irrigated agriculture. At first, an almost mechanical marriage of these two sectors is to be expected in order to achieve their integration later. Pastoral livestock husbandry, a sector that still repays itself economically, may concentrate on raising young stock for its further fattening in the irrigated farming zone.

In closing, let us note that nomadic livestock husbandry should apparently be distinguished from nomadism, the phenomenon embracing all facets of life of the livestock-breeding population and causing another few millions of people to migrate continually. The Soviet Republics of the East found effective methods of maintaining pastoral livestock economy as a production sector that have long since paid for themselves, simultaneous with the sedentation of the nomadic population. Their experience is therefore of great interest for newly emerged countries now building their independent national economies.

EFFECT OF VEGETATION ON PRODUCTIVITY OF SOILS IN KAZAKHSTAN'S DESERT ZONE

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Vegetation of brown grey-brown soils and solonetz soils of Mangyshlak and Oustjurt as well as of grey-brown takyr-type soils of the Syr-Darya Basin within Kzyl-Orda administrative area was investigated to evaluate the importance of the desert zone vegetation for the matter/energy cycle and to determine its role in the soil-formation process.

Overall phytomass accumulation is low (64-209 cwt/ha), the structure of soils being typically desert. The content of plant roots is very high, ranging from 65 to 92%. Xerophyte and halophyte vegetation of natural phytocoenoses features a high ash content (9-33%) and has a considerable effect on the salt balance of the soils. The total of ash element inputs in the soil as a result of annual falling-off mineralization amounts to 209-395 kg/ha, of nitrogen - 16-68 kg/ha.

At Mangyshlak, the amount of photosynthetic active radiation input per vegetation period is 6.0 bln kilo-calories per 1 hectare. Proceeding from the quantity of energy used annually to assimilate organic matter, we find that the actual coefficient of PAR utilization (Kt) in natural desert plant communities is equal to 0.17-0.5%, and of subaerial mass - only 0.03-0.10%.

By contributing to the soil 22.6-70.8 cwt/ha of plant residues annually, the phytosphate of the desert zone improves the physical properties of the soils, increasing their porosity, aeration, energising the microflora; it also maintains the equilibrium condition of the humus envelope. However, despite the powerful input of solar radiation, its efficiency is negligible and therefore the productivity of soils is low.

In the conditions of Kzyl-Orda administrative area, with the rice yield of 60 cwt/ha, more than 2% of PAR is accumulated, of which subaerial mass accounts for 1.24%. Considering that Kt of PAR of sub-aerial mass on takyr-type soils equals 0.22%, the efficiency of land-use for rice cultivation increases almost sixfold.

Alfalfa sub-aerial mass produced on the brown soils of Mangyshlak contains $57.25 \cdot 10^6$ kilo-cal/ha of energy, i.e. 0.95% PAR, which is 10 times the reserve of energy available in the natural phytocoenoses.

In view of the low capacity and highly intensive biological cycle of matter, the formation of a humus envelope in the desert zone is a very slow process. Since humus is the main energy accumulator, and the energy indicates the soil productivity level, the importance of preserving the humus sphere and enriching it with power resources becomes clear.

The productivity of soils can only be raised by radical interference designed to improve the vegetation cover, serving as a capacitor and transformer of solar energy in the biosphere (undersowing of grasses, fertilization, increasing moisture content, etc.) and to replace the natural vegetation cover by cultivated highly productive phytocoenoses. This will make it possible to increase the coefficient of actual utilization of PAR to 3%, which will be 5 to 16 times the amount of energy accumulated by natural vegetation.

THE USE OF NEW SYSTEM OF NON-IRRIGATED FARMING IN THE DRY-STEPPE AND SEMI-DESERT ZONES OF THE USSR

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The paper discusses theoretical aspects of a new system of

non-irrigated farming - "Strip Farming in the Arid Zone" (Author's Certificate No. 609500). Using the system of A.A.Rodeh and A.F. Bolshakov at Janibek as a prototype, the system in question has a prime objective of developing and stabilizing dry farming on non-arable and unproductive lands in the dry-steppe and semi-desert zones.

The underlying concept of the system is to produce an artificial linear integrity of the soil cover and micro-relief. A strip land tract consists of arable flat-bottom shallow ravines divided into checks by low earth bunds and of dual-slope unsown ridges, their crests occupied by shrubs planted in single line. The soils for the ravines of minimum 0.6 m thickness are formed using the top humus layers brought together from all over the area; material for the ridges is a soil completely devoid of humus, even saline, removed from the bottom of the ravine. To provide enough moisture for the shrubs, they are planted in a small trench arranged in the middle of the ridge.

In the development of a strip farming system and in the assessment of its future prospects, "geonics" and soil/ecological engineering approaches are used, which include:

- applying the principle of concentrating, on a part of the area, the resources of moisture and fertile soils, borrowed from the natural alkalinized complexes of dry steppes and semi-deserts;

- replacement of arboreal species by shrubs, which are more resistant in the zones under consideration;

- increasing the moisture-holding capacity and the thickness of the root zone by stratifying the soil or by arranging a semi-penetrable lithological screen of the fill-up layer.

Considerations based on geonics, in particular, on the regimes and mechanisms of migration of moisture and salts in the soils of alkalinized complexes enable us to make a favourable and reliable forecast regarding a number of aspects of strip farming substantiation, and among other things, to foresee the development on the arable strips of land of the analogues of grassland-chestnut non-saline soils with the required water-physical properties, erosion-resistance of soils and of the artificial micro-relief. In addition, these considerations allow to predict the formation on the ridges of semi-desert biogeocoenoses which can be used for post-harvest cattle pasturing.

Schematic calculations and evaluations, based on segregating the experimental data on dry farming in the dry-steppe zone allow to substantiate the balance and regime of moisture, salts, nutrients and to assess the anticipated productivity of strip farming.

In spring, the strip soils will have a minimum reserve of productive moisture of 250 mm, of which 200 mm will be in the 1.2 m layer. In the sub-arable layer (20-60 cm) the spring reserve of productive moisture is 90 mm, of which 45 mm is transient. To ensure this, the fill-up horizon should contain at least 2.0% of humus (on loamy soil); this is also necessary for the nutrition of plants. In this case, there will be an increase of the depth of maximum dried-up soil layer to 1.0 m, and the needed regime of moisture reserve consumption in spring-time with about 80 mm conserved for the period of grain juicing, the early spring crops averaging 22-25 cwt/ha.

The findings of the research programme conducted at Janibek stationary research centre of the USSR Academy of Sciences prove the possibility of growing some arboreal and shrub species (particularly good prospects are for Russian olive), of desalinization of arable lands receiving extra water, of raising the yields of some crops, including wheat.

Evaluation of agro-climatic conditions on the basis of moisture balance, with due allowance for the limitations imposed by severe dry winds, makes it possible to conclude that the southern frontier of the likely strip farming spread punctuates the southern part of the sub-zone featuring brown semi-desert soils, bypassing large sand tracts.

Adequate moisture of the soils in the sown strips is ensured by achieving a proper correlation between snow-trap and strip areas /A /, and inside the strip tract - between the width of the ridges and the strips /W /, the zone holding good prospects for strip farming characterized by the assumed values $A \leq 4, W \leq 3$.

Reclaimable potential of virgin lands with strip farming is estimated at 30 mln ha (net), situated mainly in the dry-steppe and semi-desert zones. The system provides for a comprehensive improvement of solonetz soils in the arable strips, i.e. removal of the alkalinized layer from the soils. Thus, strip farming can be applied on the plains with loamy and saline lands, except the areas where groundwater with high mineral content is close to the soil surface (2 m).

Strip farming trials can be recommended also for part of the low-productivity arable lands of the dry-steppe zone of the south black and chestnut soils, especially those alkalinized. The advantages of strip farming over conventional systems (higher and more stable yields) are due to greater accumulation and more efficient use of soil moisture resources: in dry and average-moisture years - at the expense of providing soil moisture at the grain-juicing stage; in wet years - at the expense of increased level of mineral nutrition provided by a thicker humus horizon.

The land-use coefficient of strip farming will be lower only during the land reclamation period (around 5 years required for complete soil desalinization) compared with fallow land (0.5-0.6 against 0.7-0.8). It may subsequently grow to 0.8 and more by means of ravine expansion.

Tentative estimates indicate that capital costs involved in setting up strip farming tracts, using no specialized machinery (bulldozers, graders, etc.) will not exceed 1,000 Rbl/ha, net. Therefore, it appears appropriate to start without delay an experimental trial and technical elaboration of the system as a whole in a number of areas, bearing in mind the prospects of increasing and stabilising the production of quality grain and animal fodder on arid lands, especially considering the limited possibilities of irrigation development.

The system is designed for areas with cold winters and a snow cover, although the concepts of "geonics" and soil/ecological engineering can be applied to a wider zone of arid lands.

EFFECTIVENESS OF INTEGRATED DEVELOPMENT OF VIRGIN LANDS FOR RICE CROPS IN THE KARAKALPAK AUTONOMOUS SOVIET SOCIALIST REPUBLIC (KARAKALPAK ASSR)

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In the economy of the Karakalpak ASSR the rice agro-industrial complex rates second only to cotton. In 1980 296 thousand tons of rice were produced, with 4,700 kilos of grain from each hectare. Rice growing in the Karakalpak Republic began in the 60's. Since then more than 100 thousand hectares of virgin lands in the northern parts of the Republic have been developed for rice crops, in that area the climatic conditions for cotton growing are unfavourable. The development of virgin lands proceeds in an integrated manner. The rice systems are complemented by housing development, the construction of schools, day-care centers, nurseries, hospitals, outpatient clinics, movie houses, clubs, cafeteria, etc.

Integrated development of virgin lands for rice crops is conducive to the solution of large-scale socio-economic problems. Each hectare used for rice crops yields 1400-1800 roubles in gross product, with 300-450 roubles as net profits. This is 40-60% higher than the return of 1 hectare of land used for cotton or other crops in the northern part of the Republic.

The virgin lands now accommodate 18 rice-growing state farms, 10 of which are operating to their full commercial capacity. Each rice-growing state farm is a highly mechanized rice agrarian complex ensuring high work efficiency. The load distribution is 16-18 hectares per state farmer, while the yield of grain rice is 80-100 tons, worth 24-30 thousand roubles. High work efficiency ensures lower cost, higher cost-effectiveness, speedier return on investm nts and higher wages for the workers.

Integrated reclamation and development of virgin lands for rice crops prevents desertification of the Amu-Darya delta; since the level of the Aral Sea is going down, the delta now is totally dry, showing early signs of desertification.

Promotion of rice growing in the low reaches of the Amu-Darya River has therefore been conducive to the conservation of land fit for agricultural cultivation.

EXPERIENCE OF BARKHAN SANDS DEVELOPMENT TO RICE CROPS

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Irrigation systems were installed in the Khorezm oasis, Uzbekistan, in the world's first-ever venture to practice irrigated farming in a distribution zone of barkhan sands. Specialized rice-cropping state farms - Begovat, Kolos, Koshkopyr, Karakum and Yangiarak - were set up in an area located in the northern portion of the Karakum central zone. The summer there is hot and dry, with the average monthly July temperature equal to + 27.9° and that of January, the coldest winter month, equal to - 2.3°C. The soils are represented largely by sandy (loose) varieties with the content of physical clay ranging from 0.6 to 5.2% but decreasing with depth. The sandy soils have a specific mass of 2.66 to 2.79 g/cub cm, volume mass of 1.43 to 1.56 g/cub cm, and maximum hygroscopicity of 0.69 to 1.12%. The one-meter topsoil layer contains concentrations of 0.16 to 0.47% organic matter, 0.03 to 0.1% phosphorus, 0.06 to 0.07% nitrogen, and 0.18 to 0.33% potassium.

Under the new procedure designed for barkhan sands development, following capital levelling and cutting banks, a 5 to 10-cm-thick layer of ground (loamy or clayey varieties) was applied over the levelled surface area. After that the checks were flooded with water at 2.5 to 3.0 thousand cub m, to promote sedimentation and compaction of the upper sand-soil stratum. After drying out, a secondary levelling was performed with scrapers of long-base graders. Plowing was done to the depth of 18-20 cm, with subsequent railing or chaining (twice) along or across the check surface.

Irrigation ditches were built in earthern channels (distribution channels) or out of flumes (composite or sectional) and an open-type diversion network was made initially. To date an intra- and inter-farm collector-drainage network (CDN) about 200-km-long has been installed on the territory of these rice-cropping state farms. Inspections of the network's condition involving an instrumental survey of its cross-section on characteristic segments showed the open-type CDN to be extremely difficult to run in the barkhan-sand environment. Indeed, intensive slumping of the slopes was seen to start off in their very first year in operation. On the data of the maintenance organizations, in 1977 through 1980 the scope of CDN clean-up operations at those state farms amounted to 800 thousand cub m.

In barkhan sands, in order to keep the diversion network operable, the slope should best be fixated and the once-accepted layout of the diversion network within the boundaries of the rice irrigation system should obviously be revised. Overly high vertical percolation through the sand bed results in rapid substitution of the water inside the check and, as a consequence, in an excessive water requirement for cropping a unit yield (gross 60-65 thousand cub. m).

On the other hand, this environment practically saves the necessity for surface discharge from the rice fields into the diversion network. For these reasons, the drainage layout along the perimeter of the rice irrigation systems and its outflow into the main drains makes a far more efficient practice.

Research has found that across the board the effect of the downward infiltration flow causes partial washout of nutrients - organic matter and nitrogen - from the upper stratum while the gross phosphorus concentration remains unchanged. Another contributory factor modifying nutrient concentrations involves suspended sediments present in the Amu-Darya water. The sediment contain 0.20% humus, 0.06% nitrogen, 0.10% phosphorus, and 0.9% potassium and other elements of nutrition.

Special trials revealed that, as sand areas were developed to rice-cropping complexes, this gave an added vigour to the related biological processes, yet another important indicator of the soils' fertility.

As rice cropping progresses the SAR of the sandy soils was found to increase, primarily at the expense of the calcium cation. With the increasing time of rice cropping, the monovalent cations trend to promote the growing total concentrations of sodium and potassium, even though the first few years of rice cropping on sandy soils witness appreciable removal of the sodium cation from them. Thus, enrichment of the absorbing complex with the sodium cation goes at once with a significant buildup of the calcium cation there, which is in itself an altogether positive factor. The data derived from analysis of the Amu-Darya ooze brought in to the rice fields pointed up a fairly high sodium concentration of 6.53 me per 100 g soil in the absorption capacity. The concentrations of calcium and potassium equalled 1.18 and 0.57 me respectively, with no magnesium found therein.

Efficient management on the rice irrigation systems on barkhan sands shows further expansion of rice cropping in the zone to be distinctly possible. In fact over 4000 ha was developed anew to rice cropping in the period of 1976-80. The application of up-to-date rice-cropping practices fosters sustained increasing yields of this valuable crop.

To boost further the productive capacity of barkhan sands, organic fertilizer should most efficiently be applied before plowing, a move that promotes the improvement of soil processes and the soil's nutrition balance. Though the application of common mineral fertilizers serves also to enhance rice yields their efficiency is comparatively low. Experiments accomplished in the recent years have established the high effectiveness of slow-acting complex polymeric fertilizers.

Further progress of rice cropping in the barkhan-sand envrironment points to the need for the design, construction and maintenance of the rice irrigation systems to be improved through incorporation of the very recent achievements in irrigation and reclamation building practices and agricultural production.

DESERTIFICATION PROCESSES AND PROBLEMS OF ENVIRONMENTAL CONSERVATION IN THE AMUDARYA DOWNSTREAM

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In the Amu-Darya downstream desertification is mainly expressed through degradation of soil and vegetative cover, large-scale salinization of irrigated soils, depletion of surface and ground water resources, formation of soil crusts, intensification of soil-forming processes, etc. Desertification is closely connected with the enhancing human impact on desert landscapes and high rate of the agricultural development of natural resources.

Intensive development of new lands in the Amu-Darya downstream has started since 1961. Irrigation development and increase in irrigation areas considerably reduced the river discharge in the downstream. In 1979 the annual runoff of Amu-Darya at Temirbai village amounted to only 10.9 km^3 compared to 37.8 km^3 in 1960. Degradation of the vegetative and soil cover, destruction of light texture topsoil owing to intensified use of natural resources lead to decrease in the rangeland biological productivity, development of secondary salinization and wind erosion processes. Hydromorphic natural systems yield to automorphic development trends, continental salt accumulation is progressing in soils, marshy and meadow soils get dried up and enter the stage of transfer to takyrs groundwater mineralization increases with the change in chemistry (rise in chlorine ions concentration), hydrophilous and tugai-type plant communities are yielding to sparse xerophyte and halophyte cover, wind erosion accelerates.

Scientifically justified large-scale detailed investigations and surveys carried out in the Amu-Darya downstream served as a basis for construction of major hydraulic structures aimed at the rational use of water resources. Among these advanced irrigation and water supply systems are Takhiatash headworks, Kuvanyshjarma, Kegeily after V.I. Lenin and Kizketgen canals. Significant works have been completed on land fertility conservation during development of new areas; rehabilitation of degraded lands and rangeland improvement have been also carried out there.

GROUNDWATER RESOURCES
OF KAZAKHSTAN

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A substantial part of the USSR rangelands (56%), constituting the basis for animal husbandry expansion programmes, is in Kazakhstan, which straddles the zone of deserts and semi-deserts with a characteristic scarcity of surface water sources.

Until recently, the prospects of searching for quality groundwater in Kazakhstan's deserts and semi-deserts had been widely doubted. However, long years of research conducted by the Institute of Hydrogeology and Hydrophysics of the Kazakh SSR Academy of Sciences have reversed this thinking and proved the availability of huge regional groundwater reserves with an estimated safety yield of 1,960 m^3/s.

Most of quality groundwater is found in South Kazakhstan. Lake-alluvial, aeolian-sand tracts of the deserts in the circum-Balkhash area, Mouyounkum, Kyzylkums, circum-Aral Karakums contain groundwaters at the depths from 3-10 to 30 m. The yields of drilled boreholes are within 430-2,000 m^3/day. These deserts also feature artesian basins essentially of fresh groundwater (confined and self-pouring) in the sand deposits of Neogene, Paleogene and Cretaceous age. This water is mainly found at the depth of 100-500 m, with a borehole yield varying from 300 to 8,000 m^3/day. According to estimates century-old resources of groundwater in

South Kazakhstan equal 4 thousand billion m^3, or 5-30 mln m^3 per each km^2 of the area. The regional safety yields are estimated at 970 m^3/day.

West Kazakhstan accounts for about 24% of the entire Kazakhstan groundwater resources, with around 16% of the stock being in Central and North Kazakhstan, i.e. 300 m^3/day. 11% of the groundwater reserves are in East Kazakhstan (470 m^3/day).

To sum up, Kazakhstan enjoys considerable groundwater reserves, capable of satisfying the needs of irrigated farming, and of rangeland watering to produce more fodder for the livestock. Rural water supply for 2,000 villages is currently based on the use of groundwater, which is also utilized for the watering of 100 mln ha of rangelands and for the irrigation of 40 thou ha. In future, extensive use of groundwater will make it possible to bring water to all rangelands, to provide water supply for the villages and to irrigate at least 600 thou ha of lands.

RIVER SALINITY INCREASE IN THE ARAL SEA BASIN AND POSSIBLE WAYS TO REDUCE IT

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In the recent years practically all "schemes" of integrated arid and semi-arid land development pertaining to the Aral Sea basin have drawn major attention to the problem of the river water quality and, in the first place, water salinity and concentration of the main ions, It was revealed, that in the course of several past decades the river water salinity in the Aral Sea basin has increased 3-4 times reaching on the average 1.5-2.0 g/l (at present) from 0.4-0.5 g/l (1938-1942); water chemistry has changed from hydrocarbonate-calcium class to sulphate-calcium class (occasionally to sulphate-sodium). Study of the river salinity problem is of immense scientific and practical interest, particularly for irrigation and agricultural experts, soil experts and geographers. Although the ingenious reason of the river salinity increase is the irrigation return flow this problem should not be studied without relation to desertification in the Aral Sea basin, specifically in the deltas of the Syr-Darya and Amu-Darya rivers.

Investigation into the problem was carried out by stages.

The first stage included assessment of TDS values and chemistry changes that had taken place in water of all river basins of the Aral Sea for the period from 1938 to 1980. Main attention was paid to the analysis of salinity dynamics at the initial cross (located upstream of oases) and the outlet (located downstream of them) ones or located at the outfalls of the rivers. If several major oases were located in the river basin, assessment of the salinity changes was performed in succession for each downstream site. Detected changes in the river salinity were represented on two maps "Salinity and chemistry of the river water in the Aral Sea basin" compiled for the first five years of record (1938-1942) and for the last five years of observations (1977-1980) at a scale of 1:2.5 mln.

At the second stage there was studied the formation of salinity and chemistry in all major oases in the catchments of Syr-Darya and Amu-Darya (up to 15 oases). Change was determined in the total salt content for each year in total, for separate oases and drains, alteration of this value was analysed for a period of one year and in relation to the length of the drain, etc. The results were reflected on a map "Salinity and chemistry of drainage water in the Aral Sea basin" at a scale of 1:1.5 mln. The increase in TDS values of the river water was compared to the increase of the total salts in-flow from irrigated areas and relationships between TDS values and salt composition were revealed as well as with change in the degree of irrigated soils salinization and salinity and chemistry of groundwater. There was plotted a correlation dependence between the salinity of river water and the main parameters of the irrigated soils condition in relation to reclamation possibilities.

At the third stage there was prepared a forecast of the water salinity changes for all rivers of the Aral Sea basin (without consideration of the Siberian river flow diversion). Estimations involved the basin method, i.e. with consideration of salt yields of the areas of ancient irrigation and newly irrigated areas. The results of estimations were compared to the forecasts made by organizations like SANIIRI, SARNIGMI, Sredazgiprovodkhlopok, etc. There were prepared preliminary recommendations aimed at reduction of the present river salinity and measures to prevent further increase of salinity in the river water were suggested. The estimations obtained served as a basis for compilation of a map "Salinity and chemistry of river water in the Aral Sea basin in future".

INDUSTRIALIZATION IN A SYSTEM OF INTEGRATED REGIONAL DEVELOPMENT OF ARID AND SEMI-ARID LANDS

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The current tasks of optimizing the use of various natural resources and their territorial combinations in the countries of arid and semi-arid regions with different social and economic conditions suggest a multitude of ways of economic development and of settlement of these areas. One of the alternative is industrial development of natural resources coupled with new and more advanced forms of local labour utilization for solving integrated problems of arid- and semi-arid lands (ASL) economic expansion under the long-term strategy of the overall social and economic development of a particular country. Such strategic approach, in turn, includes the setting up of an appropriate infrastructure and the use of increasingly aggressive and diverse means of combating desertification.

World-wide, there exists a record of ASL industrial development, the importance of these areas steadily growing from the standpoint of resource availability, development of power engineering and other basic industries, including power- and material-intensive types of production. In the USSR, mining industry has become an important factor of desert development. Arid lands of the USSR supply roughly 1/3 of natural gas, about 1/7 of its oil and coal, all kinds of ferrous and non-ferrous metals, chemical products. Based on the mineral raw materials, production-territorial complexes of an industrial or agro-industrial specialization are formed, new cities emerge. Thus, on the basis of the Nurek Hydroelectric Power Plant and Yavan Electrochemical Works and other industrial enterprises the South Tajik Production Territorial Unit is being developed. The commissioning of an atomic desalinizing installation in the city of Shevchenko on the Caspian Sea made it possible to begin an integrated development of productive forces in Mangyshlak Area, West Kazakhstan. An illustrative example of new cities is Navoyi, a blooming city in the Kyzylkums, built in view of the construction of the mining/metal works and a chemical plant.

The problem of industrialization of developing countries acquired a broad international significance after dozens of newly independent states came into being in Asia and Africa. It is in industrialization that they see a way out of the vicious circle of staying underdeveloped, a condition these countries inherited from colonial or semi-colonial past. Their lop-sided specialization (agriculture and raw materials) means that processing industries are either at an embryonal stage or do not exist at all. The emerging national industry helps in solving many of the vital social and economic problems: employment, import replacement, export "ennoblement", etc. It can be an important factor of spreading technological progress, of changing the structure of other economic industries, of raising the standard of backward and of developing the new regions, including ASL.

Even now, in many arid Afro-Asian and Latin American countries, especially those producing oil, there is a growing importance of desert and semi-desert mining centres for GDP formation. Apparently, this is so largely because geologically, tectonically and geochemically arid lands possess huge and not yet established resources of energy and minerals. For example, in Algeria, utilization of oil and gas deposits in Sahara alone accounts for much of the country's GDP. Based on accelerated industrial development, Algeria for the past 20 years has been transformed from an agrarian-monoculture into an industrial-agrarian country with a first-rate oil/gas and petro-chemical industry and good prospects for further development. After oil and natural gas had been discovered in the Algerian Sahara, the look of this desert land began to change. Modern mining settlements were formed around the oil and gas fields, many kilometres of motor-roads were built and of pipelines laid. In the last few years, efforts are under way to set up a "green barrier", a wide afforestation belt at the desert border to control the advancing sands. There are many more interesting and instructive examples of development through industrialization of natural resources in various countries and areas of the arid zone, featuring different levels and trends of social and economic development.

Where developing countries have considerable areas of deserts and semi-deserts, effective combating of desertification can and should be combined with industrialization efforts, if possible, on the basis of more comprehensive development of their natural resources. As it is, a multi-plan process of industrialization cannot, as it used to be in the past, be hinged on a single-purpose use of a particular natural resource, however considerable its reserves, and on setting up industries specifically to utilize the resource. The peculiarities of each developing country predetermine the particular ways, methods and stages of solving these problems.

What must be noted is the important, sometimes pioneering impact of individual industrial projects on the formation of a sectoral, and, to a smaller extent, of a territorial economic structure of a developing country. Nevertheless, it seems that a much greater effect is achieved when such projects are part of industrial units, which include a number of enterprises unified by a particular economic function and having stable production links. Production units of this kind are definitely important for shaping a particular territory which contributed to territorial economic integration. This will give impetus to overcoming the social and economic backwardness of peripheral, marginal areas. The priority of an integrated approach to natural resources development through industrialization facilitates the introduction of technologically more advanced stages of processing the energy and mineral resources, the transition to setting up modern processing industries.

The establishment of major units of this kind in the developing countries becomes possible and is often encouraged by the cooperation of other nations, socialist countries included. The USSR and other countries, members of CMEA, have for years been cooperating with developing countries. For example, there are many industrial and infrastructure projects built or under construction with the aid of socialist countries in Algeria, Iraq, Syria, Libya, Democratic Yemen and elsewhere. These countries abandoned the construction of individual projects and are now cooperating in the setting up of economic units based on modern technology and scientific research. A good example of this is "Olmos" Project in Peru intended to develop vast areas of arid lands in the north of the country. Implementation of this project with the assistance coming from the USSR will help to transform a large Peruvian region. When socialist countries participate in the execution of projects in arid regions of developing countries, as in the above-named case, special environment protection measures are envisaged. In particular, production processes with low water demand are being developed, recycling water supply systems, recultivation measures in formerly mined areas, etc.

Owing to its integrity, UNEP opens up good prospects for industrial and geographic studies, for carrying out applied research programmes in the field of ASL development through industrialization in the countries of Asia, Africa and Latin America. This is a complicated and priority task facing the scientists and regional planning experts, administrators of equal scientific and technical international cooperation.

ROLE OF PRODUCTION INFRASTRUCTURE IN ECONOMIC DEVELOPMENT OF ARID LANDS

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Natural development of industry, transport, uncontrolled urbanization in the arid zone frequently leads to increased degradation of the environment. The USSR has a long history of successful drawing up and implementation of integrated programmes of industrial development of arid lands, based on reasonable sociological and ecological principles.

A key condition of an integrated development of an area, especially arid, is priority development of a production infrastructure (PI), i.e. of a group of industries designed to support and service the basic industries of material production and the population. PI includes the following main subsystems:

- all kinds of transport functioning in the sphere of circulation, including power-transmission lines and other installations for the transmission and distribution of electric power;
- information-communication system;
- system of providing material resources for production: material and technical supply, procurement, water supply;
- engineering infrastructure, including all kinds of engineering support and city transport;
- business "service": adjustment and management;
- infrastructure for the protection of environment.

PI subsystems functionally make up one whole; they possess a number of common specific properties determined by the PI objective: provision of conditions for production and life of the people:

- high fund and capital capacity of PI projects, long time needed for their construction and long periods of functioning;
- the major effect of PI (90%) is in the basic industries, hence the view that investments into PI are "not worthwhile";
- processes of PI output production and consumption are inseparable; as this output is not material, it cannot be accumulated or stored, which calls for reserve capacities;
- considerable seasonal, monthly and daily irregularity of load among the elements of PI, and of its output consumption;
- prevalence of spatial-network structure;

- functional lag (elasticity) due to discreet development which often results in underestimating the need for more capital investments to reinforce PI projects and networks;

- functional interchangeability of PI elements: modes of transport, transport and warehouses, transport and communication.

Being a powerful distribution factor, PI integrates economic space and, functionally, should be regarded as an inter-sectoral complex, requiring an integrated inter-sectoral management.

In arid lands, where developed areas are valued most, particularly important is the possibility of concentrating compatible PI linear projects in special corridors of communication, which makes it possible to achieve a minimum 10% saving in areas.

There is one subsystem - water supply - which plays a special role in arid lands. In the USSR, the basic funds of this subsystem are estimated at 70 bln Rbls, i.e. it accounts for about 8% of all basic production funds. It is a matter of top priority to raise the efficiency of this subsystem through improvement and making use of the water use reserves: better utilization of irrigated lands, control of seepage losses caused by the low engineering level of canal network and irrigation methods, wider introduction of cycled water supply in industry, reducing the volume of water diverted from natural water sources through the introduction of cycled and closed water supply systems, technologies that require no water and produce little waste, bringing down water losses in water supply networks.

Infrastructure for environment protection is characterized by a high rate of development and a fast growth of capital intensity. Under the extreme natural conditions of arid lands, not only waste treatment techniques are improved but means of preventing environmentally dangerous emissions into the environment are developed, and above all, waste-free production processes as well as devising ecological monitoring systems designed to determine industrial and domestic pressures on the environment.

In many of the world's dry land habitats, a system of transport called upon to satisfy the requirements of population and national economy, is still at an early stage of development and continues to be one of the most vulnerable industries. In planning transport facilities for arid lands, the vast regional differences in transport service requirements are still being ignored, which also applies to phased development of infrastructure, economic substantiation of the correlation between the main routes and local networks, between new road construction and rehabilitation of the existing network. There is a certain arbitrariness in the determination of an economically justifiable technical level of a project, required capital inputs, requirements of manpower and material means. The present level of transport development in industrialized countries is often used as a criterion. While planning the development of a transport network with limited financial and material resources, it is highly important that the cost/benefit analyses of a particular project should be proceeded by economic and geographic surveys, i.e. comprehensive indices to evaluate regional differences must be devised and applied: availability of transport networks, requirements of transportation services, extent to which the available transportation network meets the requirements of the region.

The specific conditions of arid lands - high air temperature, intensive solar radiation, increased dust content of the lower atmospheric layers, soil salinity - it all necessitates modification of the means of transport towards improving their operational reliability.

At present, the contrast between the growing need for PI and the state of its development is most apparent in the newly-developed areas. Adaptability of population there and the improvement of the quality of life can be realized above all with a developed infrastructure.

OPTIMIZED NATURE MANAGEMENT IN ARID ZONES

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Optimization of nature utilization represents one of the cornerstone problems in the economic development of arid zones.

9 million square kilometers of arid land owe its existence to man. On all continents desertification has assumed hazardous proportions. Degradation progresses at an annual rate of 50 thousand km^2, which suggests that the process has recently become more vigorous. Desertification results from injudicious use of natural resources under extreme natural conditions. Conditions for possible desertification are also provided by such natural properties of arid zones as low variability of species, unstable intercomponental relations, moisture shortage, underdeveloped soils, high susceptibility to external factors, pliability to water and wind erosion, ups and downs of natural rhythms caused by long dry periods and general instability of arid landscapes.

Among the man-induced factors of desertification the worst ones include a disturbed relationship between natural climate fluctuations and changes in the patterns of land use, when periods of excessive moisture increase "pressure" on soil, cultivated areas become vaster, livestock numbers increase. This unbalanced land use leads to "overutilization" of a particular area and to a disrupted balance, which can only partially be brought back to normal, though at a lower productivity level, when the new dry period sets in.

However, instability of arid systems and their vulnerability to human impact is counterbalanced by their prompt responsiveness to reclamation efforts. Used judiciously, arid territories will preserve their productivity: when deliberately preserved, they will rapidly restore it.

Management of the natural environment of arid ecosystems must begin with obtaining reliable information covering the available natural resources, collection and interpretation through standard techniques of monitoring data. The best technique to do that would be large-scale landscape surveying which would make it possible not only to take inventory of the available resources but also to arrive at the landscape variability and to monitor changes occurring under the impact of different types of economic activity. Monitoring can cover changes in vegetation, especially such indicators of long-term changes as trees and shrubs, adverse phenomena and processes (deflation, formations of sand dunes, erosion), changes in the desert boundaries, changes in the nature and structure of land use (rangeland area, cultivated land, sites for timber procurement), the number of livestock and its composition, population migration, etc. These data bring the understanding of landscape vulnerability, stability thresholds cumulation effects and lag phenomena, the rate and trends in landscape changes, etc.

The next step should be a study of the mechanism and models of desertification to arrive at judicious utilization principles as a means of desertification control.

The final stage is represented by the optimization of arid landscapes, a procedure that should not be understood as an attempt to maximally increase their productivity, but should be conceived to preserve the basic ecological processes and life-supporting systems in arid areas, to promote its unique genetic diversity; at this stage an optimal land use strategy must be identified, including alternative energy sources. Formulation of a long-term program to use arid territories must rest upon a study of anthropogenic landscapes, which are open systems in need of having a particular state supported by society within tightly controlled parameters. Planning must become an important component in the management of such systems, aimed at arriving at rational proportions between the consumption of natural resources and the compensatory capability of the system itself.

PAKISTAN: PROBLEMS OF DESERTIFICATION UNDER CONDITIONS OF IRRIGATED FARMING

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Pakistan represents a striking example of the country where desertification processes are attributed to human activity and primarily to the irrigated farming management. On the World Map of Desertification prepared for the UN Conference on Desertification by UNEP, FAO, UNESCO and WHO the country's territory is marked as an area subject to "high" desertification hazard while on the Map of "Desertification Level of the Hot Arid Regions" compiled by G.Dregne (USA, 1977) the level of desertification is marked as "severe" in this country.

Pakistan is an agroindustrial country. Irrigated farming is the core of its agriculture. Major farming crops are wheat (44% of the total cultivated area) and cotton (12%).

Nearly 60% of the total Pakistan area is occupied by mountains - Hindukush and Iran upland (north and west of the country). Other portion of the country is the Indian lowland - the principal farming region where nearly 80% of the country's population is concentrated.

In recent years rapid growth of population and inadequate rates of agricultural production have resulted in the necessity to import significant share of food-stuffs. This country possesses vast areas of virgin lands suitable for cultivation. However, development of farming is limited by widely spread saline soils and a shortage of water for irrigation. Under conditions of dry tropical and, in general, continental climate the Indian lowland receives from 100 to 250 mm of rainfall annually. It is distributed chiefly during a hot dry season thus being rather low-efficient. The river runoff is insufficient for irrigation of the required area of farming plots.

One of the most important problems of the country's agriculture is the development of desertification induced primarily by irrational economic practices, including: deforestation (particularly in the mountainous, mostly humid regions), overgrazing, cultivation of sloping and watershed areas, application of ecologically unsound irrigation systems. According to S.V.Zonn's classification, the whole territory of Pakistan represents an arid-monsoon type of desertification that results in the formation of dry tropical deserts and semideserts of peculiar nature.

Of all agricultural lands (irrigated lands, rainfed farmlands, rangelands) amounting to 75.3 mln hectares in Pakistan 86% is subject to desertification, as to Dregne's estimates. It includes over 40 mln hectares, i.e. nearly half the country's territory, which are subject to wind and water erosion. Approximately 1.5 mln hectares are affected by drifting sands (Thar and Thal deserts border the Indian lowland in the north-east). However, progressing salinization of lands is the major negative consequence of unwise land use practices.

Irrigated area in Pakistan makes up 13.3 mln hectares or 73% of total arable land area. 5 mln hectares of that number are subject to desertification having salinization as its primary indicator. The following factors contribute to the development of this process: dry climate, availability of groundwater in the vicinity of the surface, low natural draining capability of areas, imperfection of irrigation systems, disregard of the watering rates. (It should be mentioned that excessive watering is to a certain extent conditioned by a traditional economic system providing for independence of the irrigation water cost from the amount of its consumption in Pakistan).

Productivity of cotton, maize, some oil-yielding and leguminous crops, sensitive to salinity, sharply decreases on cultivated lands with the increase in soil salinity. Further on these crops are practically eliminated from rotations and replaced by more salt-resistant crops like rice (under conditions of adequate water for flooding irrigation). Otherwise, land is left fallow and upon further salinization abandoned.

According to some estimates, annually nearly 50 thousand hectares of earlier cultivated lands are abandoned due to salinization. As it was mentioned in the report of one of the international commissions, surveying the territory of present Pakistan in the fifties - if these rates of salinization remain "without taking efficient measures the Indian valley will become a desert in some fifty years".

To prevent development of desertification in Pakistan a comprehensive programme was elaborated in Pakistan in 1958 and after that work on soil reclamation for averting salinization was initiated. These measures are implemented mainly within the framework of SCARP projects (projects of combating soil salinization and of land reclamation). The country's territory is divided into 26 regions according to the number of projects. Wells are drilled on the reclaimed land to decrease the groundwater level and to provide additional water for the leaching of saline soils.

A project of Mona reclamation (area of 45 thous. hectares) involving one of the most representative irrigated regions of Pakistan was the first experimental SCARP project. By early sixties 90% of the soils in this region was subject to waterlogging and 20% - to salinization. As a result of reclamation measures (during 10 years from 1965) - application of vertical drainage in combination with a more advanced system of drainage, the groundwater level reduced by 1-2 m which enabled to minimize waterlogging and restore fertility of 80% of the saline lands. Crop productivity has increased by one third on average and population of cattle has risen 1.7 times. Thus, the experiment turned successful and the experience gained was recommended to other areas of the country.

By now, several thousand wells have been drilled as to SCARP programme. Along with state wells, private wells and bore-wells have been drilled. Beginning from 1967, large reservoirs are under construction on the rivers (with efficient capacity of over 6 km^3) for the regulation of surface runoff.

It should be noted, that similar technical measures affect mainly large farms specializing in commercial production and hence gaining greater profits from these innovations. The majority of farms (over 68%), however, due to the existing social and economic conditions are not able or interested in implementation of the mentioned measures. Therefore, they are practiced locally and on limited areas. This demonstrates that even under condition of technical feasibility of successful combating desertification social and economic relations can serve as a limiting factor.

EXPERIENCE OF INTEGRATED DEVELOPMENT IN THE THAR DESERT

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The Thar Desert is India's largest arid region located in the west of Rajasthan along the Indian border with Pakistan. With an area of 208.5 thousand sq km and a population of over 13 million, the Thar desert has a population density (16 per sq km) second to none among the world deserts (the average of 3).

In terms of principal economic and social indicators, Rajasthan's arid districts rank among the most backward in India. This is due to the underdeveloped socio-economic structure, a heritage of the feudal system. Following the partitioning of India in 1947, the Rajasthan esert became the country's peripheral outlying area, having lost its traditional contacts with the centers in the Lower Indus plain.

As much as 70% of the gainfully employed population in the arid region goes in for farming - primarily dryland farming known to be low-yielding and directly dependent upon weather conditions. In the not infrequent droughty years the yield losses may be as high as 90% of the potential crop. The potential for extensive agricultural development has been practically used up, for the extent of land plowing has come close to the maximum allowable one (an average 45%). Livestock husbandry (primarily nomadic) employs a bare 2.3% of the population although it constitutes the leading production sector in the most arid part of the desert. Expanding livestock numbers against declining range areas (because of the plowing) leads to ever increasing stocking pressures upon the land (80 animals per 100 ha or greater) and degrades the range areas to the condition of wastelands; hence forage shortages and the ensuing low productivity of livestock husbandry. The prospects of improved cropping and livestock productivity are directly associated with the possibility of irrigation. The percentage of irrigated areas is generally low, never exceeding 1% over one half of the area and 10% over one third, and rising above one half in the Ganghanagar district alone.

Expansion of irrigated areas in the desert is effected via three large irrigation systems attached to the Ganges, Bhakr and Rajasthan canals. The Ganges canal zone contributes around one , fourth of Rajasthan's total output of wheat, gram, cotton and oil-bearing crops. The Rajasthan canal ranks among the largest hydro-engineering projects in the capitalist world. Its area of influence equals to 32 thousand sq km, or 16% of the arid region, the canal following the completion of its construction Phase 2 originally planned for 1980, will be expected to supply water for 1.2 million ha. The project design suggests integrated development of an extensive arid space and resettlement of up to 2 million people into the irrigation zone. By the end of the 1970s, however, the actually irrigated land had reached no more than 10% of the design area.

Since the mid-1970s the Central Government of India and the Government of the Rajasthan State have been maintaining programs to accelerate economic development of the arid region, cover gaps between the income levels of different social strata and combat desertification.

1974-75 saw the work under the Programme for Drought-Prone Regions begin in ten out of Rajasthan's eleven districts. Financed by the Central Government of India and the World Development Bank, the program seeks to stimulate development, primarily of "minor" irrigation; increase the productivity of the arid rangelands, improve the quality of livestock, secure forage stocks, perform land surveying and nature-conservation measures, and install an agricultural infrastructure.

During the Fifth Five-Year Plan period the State Government of Rajasthan launched a Desert Development Programme in some of the arid districts affected by the former Programme. The two Programmes show not merely a measure of territorial overlap but also have a great deal in common in terms of the measures to be carried out within either Programme's framework. Nevertheless the Development Programme gives greater consideration to the diversity of economic structures and natural conditions in the arid region; in the three most arid livestock-breeding districts emphasis is made on the development of livestock husbandry and in another five arid and seven semiarid districts, on the expansion of dryland farming and management of rural trade in milk, meat, and wool. The Programme's implementation to date has already brought an increase of the per capita income by about one third in 20% of the villages in the Jodhpur and Bikaner districts.

The contribution from industry in the arid region is so far restricted to supplying local needs even though the area possesses some valuable industrial resources, above all raw materials of the livestock origin, such as wool, hides, skins, and milk. National importance goes to the reserves of copper ores and some non-metal minerals - gypsum, limestone, marble, ceramic clays, and kaoline.

But in the absence of a local demand and because of the poorly developed transport network, the use of the resources remains heavily limited. The weakest link in the arid region's natural resource base is a virtually total lack of energy resources, with 98.4% of the energy supply imported from other regions and the power consumption rate way below the national average.

The State Government provides incentives to boost industrial development in the arid region through crediting, offering tax benefits, providing raw materials and electric energy and initiating industrial "parks". The latter represent sites equipped with an industrial infrastructure and intended for the allocation of small and medium-size privately-owned utilities. The parks, currently installed in Jodhpur, Bikaner, Pali, Ganganagar, Hanumangarg and Nagaur, are expected to act in the future as industrialization foci. Yet for the time being the efficiency of the production units located in the "parks" is low and private entrepreneurs are reluctant to invest in them.

The arid region development programmes now underway have been thus far unable to change decisively the economic and social situation in the region. Even though some districts and economic sectors did achieve a certain measure of success in their development, particularly in the areas of influence of large-scale irrigation systems, this has not led to increasing well-being of all strata of the population, proclaimed to be the single most important goal of state programs in India. Though declared as integrated in character, in reality the development programmes fail to achieve the needed extent of coordination and integration of the measures involved, nor do they consider adequately the region's specific features - natural and socio-economic; hence the duplication of effort between the programs and the related dissipation of means and resources.

Similarly, they tend to under-estimate the need for preliminary execution of socio-economic reforms and gaining the support of the local population. For the programs to be genuinely integrated in character, requires an improved economic-geographical justification of the planned measures and consistent realisation of the formulated programmes via effective institutional mechanisms on all territorial and administrative levels.

PROBLEMS OF WATER SUPPLY IN INDIA'S ARID AND SEMI-ARID LANDS

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Improved water supply of arid and semi-arid lands is a precondition of their successful economic development. This is particularly important for India, whose population accounts for 15% of the world total, while its proportion in the world's annual river runoff is only 6%.

As regards water resource availability, the states of Indian arid and semi-arid zones can be divided into three groups: (a) those characterized by absolute water deficit, caused by lack of precipitation and river runoff (West Rajasthan, Saurashtra and Kach Peninsulas in Gujarat). In the most arid areas of Rajasthan-Bukaner and Jaisalmer - maximum annual rainfall is 160 mm. Within Saurashtra and Kach Peninsulas, 1 arable hectare gets only 8.6 cm thick layer of fresh water (Indian average - 115 cm); (b) those characterized by relative water deficit, caused by the discrepr cy between the growing water consumption and available supply (South Haryana, West Tamilnadu). In 1980, large and medium-size irrigation projects of Tamilnadu used 96% of the usable surface flow. Intensive irrigation development in Haryana left no reserves in the state's surface water resources. Also, the states of these two groups face rather bleak prospects of utilizing groundwater resources; already 92% of the renewable groundwater resources are being used in Gujarat, and 97% - in Haryana); (c) those having enough water resources but underutilizing them (western districts of Madhya Pradesh, Andhra Pradesh, Maharashtra, Karnataka, situated in the rain shadow of the Western Guts). It is within these states that the basins of large rivers are situated: the Narmada, Godavari, Krishna. Only 20-30% of their water potential is being used at present.

The strategy of improving the water supply of arid and semi-arid lands should be developed considering the peculiarities of water problems in each group of states. Under the Constitution of India, the water resources utilization is the competence of respective states, and therefore the planning and implementation of water management measures is the responsibility of states.

Arid and Semi-Arid States

The history of Indian water management industry shows that it suffers not only from lack but also from mismanagement of water resources. While the problem applies to the country as a whole, it becomes particularly acute in the arid zone areas, where water resources are limited. Here, maximum mobilization of the local water consumption potentials is required: small-scale irrigation development wherever possible, minimizing water losses in the distribution irrigation network, combined use of groundwater and surface flow for irrigation, recycling the water at industrial enterprises, etc.

When operating large and medium-size water resource projects, it is essential that their capacities be fully developed. Thus, in 1975, the country utilized 90% of its large and medium-size water projects, whereas in Gujarat - only 66%, and in Maharashtra - 65%. During the years of independence, India substantially expanded irrigation development, but the increase of irrigated lands is still a slow process. A realistic solution of the problem lies in shortening construction periods. For example, in Andhra Pradesh

State, the total irrigation potential of projects under construction since 1947 is 1,067 thou hectares, encompassing arid and semi-arid lands only. Of this area, by 1980 only 610 thou ha were introduced into agricultural production.

State of Absolute Water Deficit

Water deficiency in these states is most apparent. The possibilities of improving the water supply situation through optimizing the local resources here are negligible, hence capital-intensive and technologically sophisticated projects.

(a) Transfer of flow from contagious river basins appears a radical solution. In India, there exists a project for partial flow transfer from the Narmada and Makha Rivers to Gujarat and Rajasthan States. Once realized, this scheme would allow irrigation of over half the area of the arid peninsulas Saurashtra and Kach and adjoining areas of Rajasthan.

(b) The difficult situation with domestic and industrial water supply justifies the current build-up of sea-water desalinization activities in the Kambay Bay as well as desalinization of local saline waters. Despite its high prime-cost, this method seems to be less attractive economically than transportation of fresh water to distant villages, used now.

States of Relative Water Deficit

These states enjoy considerable water resources, and their large-scale utilization was the basis of rapid economic development. In the immediate perspective, rationalizing the water consumption pattern should include two groups of mutually complementing measures:

(a) Improved regulation of the surface flow and subsurface runoff. Most of the monsoon flood flow of the Indian rivers is not used because of the lack of flood control reservoirs. For example, the Kaveri River runoff is almost entirely unregulated, although this is the main river of Tamilnadu State. So, the construction of new reservoirs can open up more possibilities for utilizing these resources. Groundwater spreading in the dry winter period on the Indian rivers by building underground reservoirs is particularly promising in the alluvial easily penetrable soils of the Indus-Ganga Lowland, including Haryana.

(b) Minimizing water requirements for production. It appears practicable to change, in the states of this group, the cropping pattern in favour of less water intensive crops. Thus, in mid-1970s, in Tamilnadu State 38% of the cropland was under rice, most aquatic grain crop, and only 0.001% was under wheat (the yield of rice per 1 mm water is 3.7 kg/ha, of wheat - 12.5 kg/ha).

States Rich in Water Resources

The main reasons delaying the development of the water potential in the arid zones of these states is the general backwardness of their economy and inter-state disputes on the distribution of the waters of borderline rivers. An early agreement on the principles of joint use of the runoff of "common" rivers will contribute to the economic boom of arid and semi-arid lands on the basis of irrigated farming. The possibilities for this are not yet fully realized. For example, in Maharashtra State of the late 1970s, in the Krishna Basin only 150,000 ha was irrigated out of 600,000 irrigable total; in the Godavari Basin - 400,000 ha - out of 1,400,000 ha irrigable total. An integrated development of the

Narmada water resources would make it possible to irrigate 2.3 mln ha in the semi-arid districts of Madhya Pradesh State.

Sporadic measures to improve the water supply conditions of arid lands can only provide a temporary improvement of the situation. The problem of water supply for India's arid and semi-arid lands should be solved radically, through coordinated application of geographically differentiated measures.

PECULIARITIES OF NATURAL CONDITIONS OF GREAT SEBKHA OF ORAN, ALGERIA, AND PROBLEMS OF MAINTAINING ECOLOGICAL EQUILIBRIUM IN THE COURSE OF ITS RECLAMATION

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The settlement problem of Great Sebkha of Oran and of small contagious saline depressions emerged following the growth of population and industrial development of the city of Oran, situated in the western part of the Mediterranean coast of Algeria. Sebkhas of the type located in the vicinity of Oran are also typical of other North African coastal areas. Their origin is due to a number of factors among which morphological structure, geological structure, hydrogeological conditions and climate are of primary importance.

Great Sebkha of Oran has an area of 298 km^2, the size of the drainage basin being 2,274 km^2. The Sebkha is surrounded by mountains, absolute elevations reaching 1,100 m. The climate is semi-arid subtropical. The mean annual air temperature is 18°C, +1°C and +44°C being the absolute minimum and maximum, respectively. The mean annual precipitation is 477 mm, its maximum amount being 1,100 mm, and the minimum - 190 mm. Throughout the year, the occurrence of rainfall is not uniform, the summer period accounts only for 3% of the required rain. Evaporation is three times the aggregate of annual rainfall. Therefore crops can be cultivated in summer only with irrigation.

The surface runoff is formed within the mountain massifs adjoining the Sebkha. Mean annual runoff to the Sebkha is 15-20 mln m^3.

The groundwater resources of the area are not sufficiently studied. Sebkha receives the flow of a number of sources with an aggregate discharge of 300 l/s. Besides, within the Sebkha area a discharge of confined waters is possible. Because the area is land-locked, all of the water influent to the Sebkha is lost for evaporation. The presence of impervious rocks and the absence of natural or man-made drainage under conditions of semi-arid climate resulted in heavy salinization of Sebkha area. The possibility of Sebkha land utilization following desalinization was considered from the following two standpoints:

- expanding residential and industrial zones of the city of Oran;

- improved supply of foodstuffs to Oran population in view of its fast growth.

Industrial and residential zones were to be expanded at the expense of two small lakes, Petit Lac and Morceilly situated on the city outskirts. The production of foodstuffs for the city population was planned in Sebkha proper.

Integrated surveys of the area were undertaken and Sebkha Basin water balance studied to support decision-making. Analysis of alternative solutions revealed inexpedience of Sebkha desalinization since the amount of water influent to Sebkha during a year and the pattern of its distribution rule out the possibility of capital leachings that would allow agricultural uses of the land and its irrigation.

Estimates indicated that the leaching and irrigation of Sebkha lands in addition to considerable capital outlay requi es 2 km^3 water extra. Again, under conditions of short water supply in Oran area, this is impractical. Even if extra water resources become available due to better regulation of oued runoff and the use of waste waters, it appears economically more advantageous to use these resources for the irrigation of fertile lands surrounding the city of Oran.

The conducted surveys indicate the necessity of preserving the natural water balance condition and ecological equilibrium of Great Sebkha of Oran, a unique natural site, a place of rest for the birds of passage.

DESERTIFICATION IN EAST AFRICA:
SPECIFIC FEATURES

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On the World Map of Desertification prepared for the UN Conference on Desertification held in 1977 the region of East Africa, including Somalia, Ethiopia, Kenya, Uganda, Tanzania is marked as "arid, semiarid and to a lesser degree subhumid zones of moderate to high desertification hazard". In spite of the environmental, including climatic, differences between the named countries there are several common features and trends in the development of desertification which specify the region as a whole.

These common features, first of all, come from the history of development, i.e. the duration of human impact on the environment. Recent archaeological findings in Ethiopia have revealed the earliest primitive agricultural devices related to the period of around 3 mln years ago. It is not surprising that just from here people started settling in other continents and this process was accompanied by introduction of a new form of human impact on the environment - swidden agriculture. However, slow millennium-long development of desertification has increased by the beginning of the XXth century due to a qualitative leap in population growth. Results of this process were noticed even later - in the second half of the century when irreversible ecological changes in all elements of the environment came to view.

Specific feature of this region is presence of areas of highly desertified lands practically in all countries although true arid conditions are typical only of Ethiopia, Somalia and

Kenya. The main reasons responsible for development of desertification in these countries are: large-scale deforestation, overgrazing and cultivation of marginal lands for rainfed farming in arid and semiarid regions.

Initial cause of environmental degradation in East Africa is the destruction of vegetation through cutting and fires aimed at development of new lands for agriculture, stimulation of young plant growth in rangelands and supplying of population with fuel and construction means. The evergreen forests covering formerly the whole area of Ethiopia occupy nearly 3% of its territory at present. Deforestation and cultivation of sandy soils in the central part of semiarid zone of Tanzania resulted in the formation of badlands within this highland region.

The process of deforestation was followed by a decrease in the humus contents of soils, enhancement of evapotranspiration and the surface runoff share, development of erosion. As a result, phenomenon of "drought frequency increase" appeared, which contained the reduction and loss of the major portion of accessible moisture by soil and the same average annual rainfall. Besides, irregularity of rainfall distribution and recurrent climatic droughts typical of the East African countries, provided additional pressure on the region's biological resources. During the recent drought of 1971-1974 being an echo of the well-known Sudanic-Sahelian drought which has caused migration of population from these countries to East Africa nearly 100,000 people died and 80% of cattle was lost in Ethiopia. In 1973-1974 over a half of cattle stock suffered from hunger in Somalia.

Even without additional extreme factors desertification is developing at present in all countries of East Africa under the impact of excessive agricultural utilization of lands in pastoralism and rainfed farming; development of marginal lands for farming under conditions of rapid population growth and increase in livestock numbers. Thus, the livestock pressure on land in the north-west of Tanzania already in 1965 ten times exceeded the carrying capacity of land. As a result of all above-mentioned factors desertification is present now in the form of erosion processes - land-slide, water and wind erosion. Along with human causes it is also attributed to predisposition of fragile ferralithic sandy soils of arid ecosystems to degradation under the action of unwise practices and due to the irregular pattern of rainfall distribution. Owing to low development of irrigation in East Africa processes of salinization and waterlogging are found mostly in Ethiopia. Desertification in the East African countries is expressed also in the decrease in crop productivity, including fodder crops which, regarding the predominantly pastoral orientation of agriculture here, affects the permanently lowering living standards of the population.

In spite of certain similarities in desertification trends in East Africa there are significant differences in the intensity and local pattern of its development in separate countries which are caused both by peculiarities of the environment and differences in land-use and socio-economic conditions. Therefore, consideration of the status of the problem in each country could make a picture of the "latitudinal profile" of desertification.

Although individual measures and programmes aimed at prevention and combating desertification are implemented in all countries of East Africa, integrated approach is practically absent and there is no coordination of actions essential for efficient control between individual institutions.

STATE REGULATION OF SPECIALIZATION IN AGRICULTURAL PRODUCTION IN ARID AND SEMI-ARID REGIONS. THE EXPERIENCE OF THE REPUBLIC OF MALI

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Administrative councils (operations) have been created in Mali as a mechanism to regulate specialization of petty-commodity peasant economy. The mechanism has been conducive to an improved food situation even in such a backward country, and in a short time has made the country the number one producer of cotton in Tropical Africa, its gross output increased by a factor of 25. The "operations" have facilitated cooperation and resulted in the emergence of first cooperatives known as "Tonne Villagois".

The public sector possesses a greater diversification capability than petty-commodity or even cooperative economic units. Specialization zones both existing and planned, are conducive to an ordered and more effective deployment of public-sector enterprises, it furnishes a science-supported answer to the questic : what public-sector enterprises and in what order should be created, which in the context of limited resources is of considerable practical importance for the newly-liberated nations?

Progressive socio-economic changes in arid and semi-arid zones resulting from specialization of agricultural production serve as a more effective weapon to combat desertification, a thesis supported by the integrated development of the southern zone (unirrigated agriculture) and the zone of the mid-valley of the Niger River (irrigated agriculture).

IRRIGATION DEVELOPMENT IN THE ARID ZONE OF MEXICO: MAGNITUDE AND ECONOMIC IMPORTANCE

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A problem of economic development of drylands is of utmost importance in Mexico that is attributed, in particular, to a rapid population growth in the areas of traditional concentration. Arid and semi-arid regions occupy nearly 77% of the country's territory as to certain estimates. Besides, within half of its area farming is feasible only under irrigation. Irrigated area makes up about 5 mln hectares in Mexico which has become an important factor in the social and economic development. The share of irrigated farming in the overall agricultural production is permanently increasing: being 35% in the beginning of the seventies it has reached 43% at the end. Moreover, irrigated areas provide a significant part of the agricultural exports.

Major irrigated districts (regions) are located in the country's north, north-east with the highest aridity degree and intense development of irrigated farming, hence changing environments of vast areas. These districts occupy over 50% of the irrigated land area. Particularly these regions gave birth to a large-scale modern capitalist production in contrast to the central and southern parts of Mexico with their traditional dispersed land-use and consumers' farming.

It coincides mainly with the fertile lands along the river valleys. At the same time, watersheds with much poorer water supply still support small half-commercial farming. With high rates of development on the basis of advanced agricultural technology (with application of fertilizers, pesticides, machinery) the large farms of irrigated districts have become mighty producers of exported cotton, wheat for large central home districts, including the capital. At the same time, the agricultural production structure of the irrigated lands of the north and north-west becomes more diversified also due to the change in the consumption pattern, especially in the cities. New irrigated areas are much more dynamic compared to the densely populated mountain basins where main food crops have been cultivated for many centuries on the depleted and erosion-stricken soils.

According to some estimates, the rapidly growing food requirement of Mexico could be met by a 4 times increase in the irrigated area with simultaneous improvement of the soil capability within the currently irrigated lands. To this end research works aimed at assessment and study of water resources in Mexico have been initiated on a large scale. They are intended to provide expansion of irrigated area, reconstruction and improvement of irrigated lands, improvement of the quality and increase of the amount of fresh water, refinement of the sewage system, elaboration and introduction of the advanced technology of salt water desalination.

However, insufficient attention has been given until now to the social meaning of the projects, to the goals of production and social infrastructure development. Integrated agroindustrial development of regions aimed at the comprehensive use of natural resources is still progressing at a slow rate. Main attention is given to the expansion and development of farming which determined a one-sided character of development. Almost complete absence of industrial enterprises, hydroelectric plants by all means halts the advance of economic regions on the basis of the existing spatial combinations of natural resources and vast labour resources. And this situation is quite typical of Mexico which has achieved true success in combating desertification.

Mexican experience proves once again that human interference with ecosystems of arid landscapes without preliminary study of their peculiarities of structure brings about unfavourable and, often, irreversible consequences. Unwise use of natural resources leads to acceleration of water deficit, depletion, erosion and salinization of soils. This, in turn, causes reduction of soil productivity and, locally, its complete degradation. Intensive groundwater intake, particularly in big mechanized farms results in the lowering of groundwater table, increase in pumping costs and the intrusion of sea water (in the Pacific coast regions). All these factors emphasize the importance of an integrated study of natural conditions and alternatives for their use in the arid and semiarid regions.

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