WATER RESOURCE MANAGEMENT IN SOVIET CENTRAL ASIA

Dissertation submitted to the Jawaharlal Nehru University
in partial fulfilment of the requirements
for the award of the degree of
MASTER OF PHILOSOPHY

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2001

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July 20, 2001

CERTIFICATE

Certified that the dissertation entitled, **Water Resource Management in Soviet Central Asia**, submitted by **Mr. Sanjay Kumar** in partial fulfilment of the requirements for the award of the degree of **Master of Philosophy**, has not been previously submitted by any other degree of this university or any other university and is his own work.

We recommend that this dissertation may be placed before the examiners for evaluation.

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Dedicated to
My Papa and Maa

ACKNOWLEDGEMENTS

Words fail me when I express my sincere gratitude to my Supervisor Dr. K. Warikoo without whose cooperation and valuable guidance this work would never been completed. In spite of his busy schedule, he always found time to spare for me not only in regard to my academic work but also for my personal problems. What's more, he encouraged me to follow the right path, whenever I showed my general tendency to go off the track. I have benefited a great deal from his learned suggestions, constructive criticism and conditions support. Without his active involvement in planning and presenting this work, it could have remained just another distant dream.

My parents deserve special mention. Their unfailing love, affection, guidance and encouragement has made me overcome many a hurdle in completing this project.

I would like this opportunity to express my sincere thanks to my younger brother Ajay and family members and my friends, Binod, Gautam, Niti, Sonam Joldan, Krishna Gopal, Gaurav and my roommate Prakash who have encouraged and helped me in many ways in completing this task.

I am also thankful to the staff of the Central Library, J.N.U. and Central Secretariat Liberary Shastri Bhawan New Delhi, for their sincere cooperation during my study.

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July 20th, 2001
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CONTENTS

PREFACE

Water plays a central role in sustaining essential life processes in the biosphere, but civilisation has also made use of it in a bewildering variety of ways; for drinking, cooking and washing, but also for altering the natural regime of biological production through irrigation; as an industrial coolant and raw material, and for the dilution and transport of waste products. It has long enjoyed a unique importance in religious ritual and symbolism, yet it has also become vitally significant for recreation and for the more utilitarian functions of transportation and hydroelectricity. Further development of our civilization depends quite heavily on improving the quality and the quantity of the global water resources.

With the exception of the air he breathes, water is to man the most precious of substances. Yet, in a sense, it is by no means conveniently distributed; about 99.5 percent of the earth's total supplies are contained in the oceans, ice caps and glaciers, lakes, rivers etc. and roughly .97% of the remainder is ground water. Further the total water quaiity of our planet estimated at 1.6×10^{18} M^3 is quite large but available fresh water is less than 0.5% of it.

World water demand has been constantly increasing with the growth of population. This population growth boosted both domestic and agricultural water demand. The quality of life has also improved which is based on the greater per capita use of the fresh water through increased consumption of agricultural and industrial products.

Through the ages, man has been evolving and developing, means to control and develop water resources. But their use has not always been wise. In many cases, potential of water resources has been overestimated, development targets have been improperly defined, alternatives have not been scrutinized, environmental impact has been disregarded, side effects have not been predicted. Even well planned water development projects may have some negative impact, which is overbalanced by the respective benefits.

So, it is obviously imperative that the use of the tiny proportion of the surface water available to us should be wisely managed by the progressive human beings of the existing advance world. Because water is a major ingredient in the physical and biological environment, providing at the same time a stage for man's economic activities, it also supplies a logical connection between the investigation of the physical and social milieu and an opportunity for the much needed integration of physical, ecological, environmental and human activities.

Central Asia is a land locked sub-tropical country, constituting one of the arid zones of the planet. Deficiency in water resource in this region is caused by various important factors like variable and spatial geographical diversity in topography, climate, drainage pattern, socio-economic activities, historical background and lack of proper water management.

Moreover, Central Asia's water resources are unevenly distributed. Most of the water supply is concentrated in mountainous area, from which all the major and lesser rivers emanate to form a rather well developed river network. After leaving the mountains, these rivers enter into desert areas, provide water for oases of land, and lose much water through filtration and evaporation. Four - fifths of this water network is located in Kyrghizstan and Tadjikistan, which have a small land area. Uzbekistan, Turkmenistan and Kazahstan which occupy larger portion of the region's land area are largely dependent for irrigation of its arable land on upstream rivers from other two Republic. The water level of the largest rivers in Central Asia, the Amu-Darya and Syr-Darya fall perilously at critical times of the year, because so much water is diverted from its tributaries for irrigation. Besides rivers there are two important lakes Aral and Balkhas. The region is also well endowed with underground water.

Before its annexation by Tsarist Russia, Central Asia was comprised of number of Khanates (in the form of oases near the water sources) and the people were capable to use and manage the local surface and groundwater for agriculture and day-by-day needs. But with the incorporation of Central Asia into Tsarist Russia and later on in the Former Soviet Union, the region's economy was stimulated and further developed. Central Asia emerged as an important region of specialized agriculture, particularly cotton cultivation and it had been supplying over two third of former Soviet Union's total requirement of cotton.

The water supply and its management had been a major issue for the intensive development of irrigated agriculture, the growing needs of industry, the demands of hydroelectric power system, the growth of cities etc. For this purpose Soviet Union constructed a number of reservoirs, dams, canals and multipurpose projects. The expansion of canal irrigation network greatly helped in the expansion of net sown area which in turn created a direct stress on the natural water cycle.

To fulfill the increasing water demand for growing population and have a sustainable water management, former Soviet governments paid much attention to this problem. From the very first five year's plan major efforts were made to deal with the water shortage allocating significant investment for developing irrigation systems, building a system of canals and regulating the flow of rivers. Soviet government had also launched the inter-republican and inter-channel irrigation network.

Inspite of these efforts there have been deficiencies in terms of sectoral supply and appropriate usages of water resource. Central Asia witnessed the acute shortage of water for industry and increasing population, problem of salinization in soil, desertification and ecological problem in Aral Sea.

It is in this perspective that this study takes up water resource management in Soviet Central Asia, as a subject of research. The issues that have been come in for examination are: what were the positive and negative aspects of water resource management in the region? The appraisal of the Soviet and local government's water policy? How over-population, urban industrialization, intensification and expansion of agriculture adversely affected the hydrological cycle in the region? What were the consequences of irrigation projects and its implications for the fragile environment and the coming generation in the five Central Asian Republics? How the diversion of stream channel into some specific regions caused salinisation of soil and consequent water logging problems leading to shrinking of Aral Sea? And how the Siberian river water diversion scheme was a major threat to the global ecology? The study is confined to the Soviet period (that is from 1917 to 1991).

Chapter one provides the Geographical Perspectives which have been associated with water resources. This chapter has presented comprehensive geographical analysis of Soviet Central Asia, such as topography, structure, relief, rainfall, natural vegetation, soil, agriculture, urban industrialisation and human resource etc. Chapter two examines the sectoral availability of water resources such as -

rivers, lakes, reservoirs and wetlands, groundwater and glaciers etc. This chapter also deals with the use of water resources in various sectors like agriculture, industry, transport, municipal and power sector.

The detailed study of the Soviet water resource management and the government policy and planning, has been discussed in chapter three. Chapter four presents a detailed and spatial study of the Siberian river water diversion its possible consequences and the end of the scheme. The concluding chapter gives an overall assessment of the water resource management, its impact on environment and future prospects of the region.

The methodology followed in this study is primarily of deductive analytical approach. Comparative regional analysis approach for studying the water resource management in former Soviet Central Asia - first by looking at the region as a whole and later by focussing on different components and aspects of the water resources. The study is based on such primary sources as ex-Soviet official reports, *Current Digest of Soviet Press and Soviet & Post-Soviet Geography F.B.I.S. Reports on U.S.S.R., Water Report of U.S.S.R., by F.A.O. and water report by W.D.R. of World Bank.* These have been supplemented by using secondary information gathered from books and articles of relevance from various other journals.

Fig. 1.

REPUBLICS OF THE CENTRAL ASIA

CHAPTER - I

SOVIET CENTRAL ASIA: GEOGRAPHICAL PERSPECTIVES

Renewable and most precious resource-water is a part of the hydrological cycle. The regimen or habit of this hydrological cycle of any region depends on the Physical structure, amount and intensity of rainfall and other climatic factors, types of soils and the nature of the vegetation cover, human activities such as agriculture and industry and the number and quality of human resources of the region.

One of the most arid and water deficit zone of the planet-Soviet Central Asia, composed of five Republics, now five independent nations of Turkmenistan, Tajikistan, Kyrgyzstan, Uzbekistan and Kazakhstan extends from the Caspian Sea in the west to the Chinese frontier in the east from Russia in the north to the borders of Afghanistan in the south. The total geographical area of former Soviet Central Asia is about 4 million km^2. (3,997,400 km^{2-}) which represents almost 18% of the are a of former Soviet Union (FSU}. Kazakhstan alone with the area of around 2.71 million km^2 covers 68% of the area of Soviet Central Asia. It is followed by Turkmenistan with an area of 0.49 million km^2 covering 12% of the area of Soviet Central Asia, followed by Uzbeistan with 0.45 million km2 area which is 11% area of the region. Kyrgyzstan and Tajikistan cover 5% and

4% area of Soviet Central Asia with 0.3 million km^2 and 0.14 million km^2 Geographical area respectively. The following table shows the % are of these five republics in respect to total area of the region : -

Table - 1

GEOGRAPHICAL AREA OF SOVIET CENRAL ASIA

Republics	Area in Million km^2	% of area in respect total area of the region
I. Kazakhstan	2.72	68
II Turkmenistan	0.49	12
III Uzbekistan	0.45	11
IV Kyrgyzstan	0.20	5
V Tajikistan	0.14	4
Total	3.99	

Sources : Geography of the U.S.S.R. 1970, Paul E. Lydolph. New York (pp-226)

Nature of Central Asian water resource, its management and possible consequences are also positively correlated with geographical phenomena. So without having an understanding of the physiography, climate, soils, vegetation, agriculture and urban industrialization and quality of human resources of the region, it is not possible to have a clear comprehension of the nature of water resource management and consequences of the policies undertaken by the Soviet Government.

PHYSIOGRAPHY

Physiography of a well defined territory or region is a major determinant of the hydrological components. As the tiltation of land determines the slope of the river basin, the hydrograph the region determines of the nature of stream flow, stream energy, cannal shape and pattern. Physiography also determines the character of porosity, permeability and aquifer of rocks. Uplifted structure of lands and high mountains influence the rainbearing winds and their perpetual snow covered peeks are the sources of perennial rivers.

Physiography of Soviet Central Asia can be categorised into three regions:-

(i) High Mountains and plateaus.

(ii) Deserts and steppes.

(iii) Plains and Oasis.

(i) <u>High Mountains and Plateaues</u> :-

High Mountain system of Soviet Central Asia, embracing Kyrgizstan and Tajikistan lies almost entierly in the south eastern portion of the region, along the Chinese, Afghan and Iranian borders. The whole north east of Syr-Darya and south eastern shore of the Caspian sea area is composed of plateues.

<u>High mountain</u> wall extends from eastern coast of Caspian Sea in the south western part of the region that is Kopet - Dag mountain (Dry mountains). This mountain system is situated in south-western part of Turkmenistan along the border with Iran. The highest peak of this mountain range is Shakhshakh peak with an elevation of 2912 M. above sea level. Though the highest point of Trukmenistan is the Airbaba peak at 3137 m, in the east on the border with Uzbekistan, Kopet-Dag is a dry mountain. So no major streams of any

proportions originate in this mountain. Only some small streams provide water for domestic use and restricted irrigation in Ashkhabad.

But for this Kopet - Dag, vast and complex system of mountain ranges occupy the South eastern part of the Soviet Central Asia. The major mountains are :-

The Tienshan Mountain System:-

It forms the most extensive portion of the mountainous section of Soviet Central Asia. It is composed of a number of separate ranges, all directed generally east west. Many of them are mottled mountains with typical isolated patches of perpetual snow. The Tienshan mountain is situated in Kazakhstan, Uzbekistan and Kyrgyzstan. The highest peak of Kazakhstan (Khan-Tengry) stands at 6,995 m. above sea level in the Tien-shan mountain range.

The northern and central ranges of the Tien-shan form part of the lower and upper paleozoic (Hercymian) folded system. The individual crests are separated by wide mountain valleys, constituting rich agricultural and pasture lands. On the frontier of the Central Asia and China, in the eastern most section of the Central Tienshan, several ranges merge into a powerful glaciated mountain hub. The Pobeda (victory) peak rises to 24,400 ft. being the highest point of Tienshan.

Pamir-Mountain System:-

South of Tienshan lies the younger (tertiary) Pamir Mountain system, "called the roof of the world" distinguished by more compact and higher ranges. It forms part of the Pamir knot a focal zone in the Alpine fold system from which high ranges stretch north - eastward along the Soviet- China frontier, south-eastward into Kashmir and Tibet and westward into Afghanistan. This mountain system is situated in Tajikistan and Kyrgyzstan Republics. It is a part of the Himalayan mountain chain and are among the highest and most inaccessible mountains in the world. The average height of this mountain range is about 4000m. Two highest peaks of this range situated in Tajikistan are Lenin peak (7126 m. high) and Mt. Communism with an altitude of 7500m which is the highest peak in not only Soviet Central Asia but also in whole F.S.U. This high mountain mass is of a plateau character in the east having ranges of deep precipitous river gorges in the west.

The Alay Mountain System :-

It is separated from the Pamirs by the Surkhab valley. Its ranges run westward from Chinese frontier and form the watershed between the Syr-Darya and Amu-Darya river systems. The crests exceed 3000m. in the Kirgyz and Tajik republics but further west in Uzbekistan, they become progressively lower, terminating in a series of disconnected hills (600-750m) high rising above the Kizil-Kum desert.

Plateaues :- are eroded uplands, the most important plateaues being Kazakh uplands, Betpak -Dala, Ustryurt plateau, Trugay plateau etc. Kazak Uplands from an extensive area of separate ranges with a general elevation below 900m. and of subdued relief. This Plateau is the divide between drainage northwards to the Arctic and interior drainage to the Aral Sea. Most of the surface of this plateau is composed either of paleozic sedimentaries or pre-Cambrian metamorphic and igneous rocks. The ancient rocks have been exposed along continued denudation and are often very rich in minerals. The Kazak -Upland lies in semi-desert and desert zones and permanent surface water is rare.

Betak-Dala Plateau is a dry plateau rising from an elevation of about 120m. at its southern edge along the Chu river northward to elevations of about 450 m., where it meets with lake Balkhash in Kazakhstan. Its western portion is composed of horizontal layers of clay and sandstone, predominantly of tertiary age, but the eastern portion of this plateau is composed of granities, syenites, porphyries, diorites and some sedimantary paleozoic strata. The Betpak - Dala has a cracked clay and salt-encrusted surface that supports only a sparse vegetation and has very little prospects for development.

Ustyart Plateau is situated between Caspian and Arab Sea in a semi-arid zone. This is a flat barren upland of nearly horizontal strata lying at an elevation of about (150-210m). In the south this plateau is confined with Krasnovidsk plateau which is 300m high.

Turgay Plateau is an area of horizontally bedded Tertiary materials standing between (180-270m) above sea level. Through the centre of this plateau runs a narrow corridor, the Trugay Gate, which forms a link between west Siberia and Turamian low lands. Apart from these main plateaus there are a number of small high lands in the region.

(ii) **Steppes and Deserts** :-

Both the Steppes and deserts (with negligible water resources) are the basic character of Soviet Central Asia. The Steppe is a more or less even treeless expanse, without surface water or swamps and covered with grass on black earth soil. The plant cover is mostly continuous, however, occasionally it is interspersed with bare patches.

Steppe has been divided into two sections : (a) The Steppe, and (b) The desert steppe.

(a) **The Steppe** :- It is found in the extreme north of the region. In northern Kazakhstan it is known as Ishim steppe or forest steppe. Here some places have moister land than proper steppe. Steppe has maximum precipitation in late spring and early summer. Here non-irrigated agriculture is feasible under favourable circumstances. The steppe in the lower limit of precipitation is suitable for agriculture.

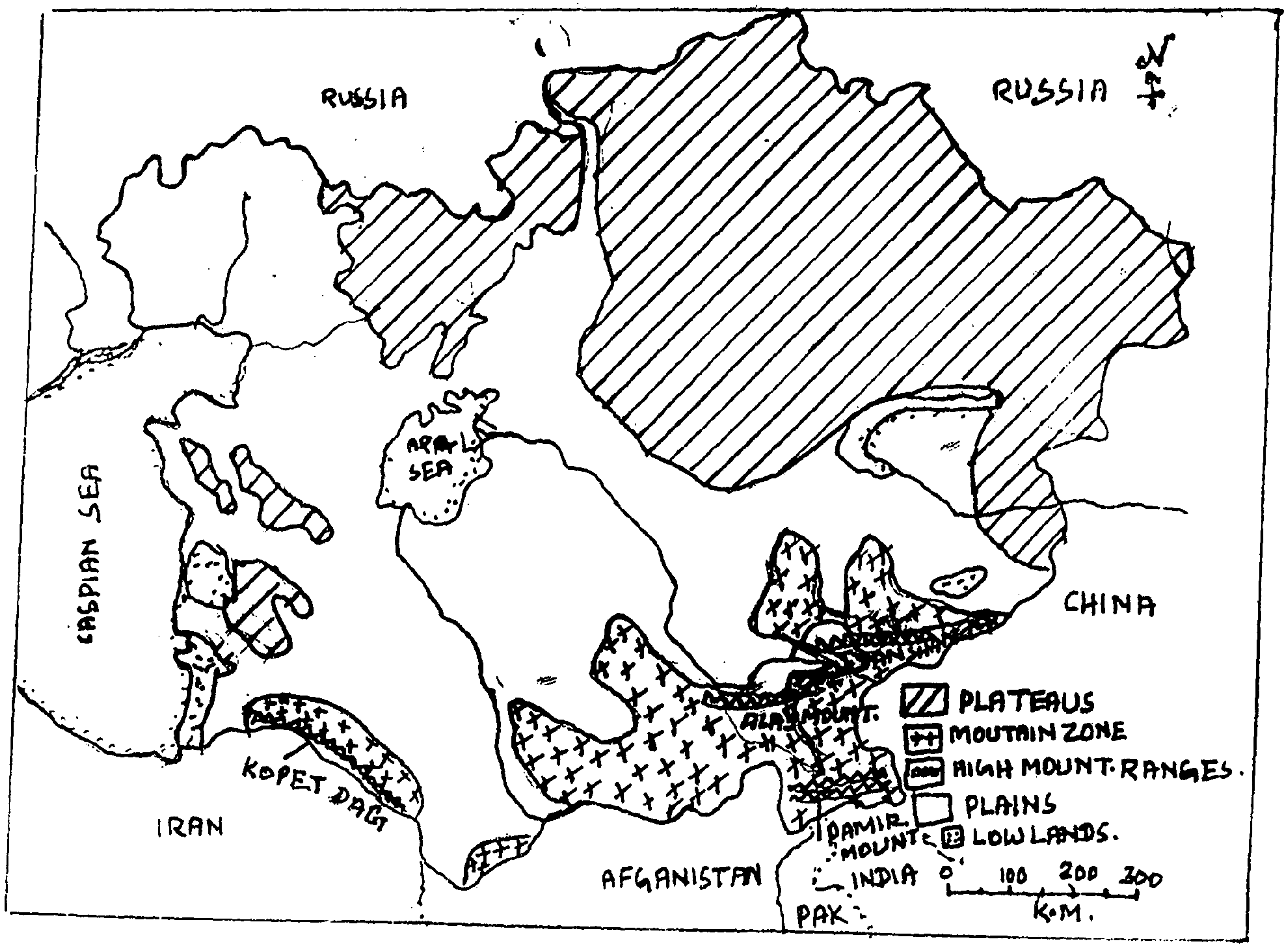
(b) **The desert steppe** :- This region lies south of the steppe, across central Kazakhstan and extends in a continuous belt across the north Caspian lowland to the Altay Mountains range. The steppe-desert is a transitional zone between desert and steppe. The plant cover is continuous and bare patches are more extensive than on the steppe. The feather grass, with deserts plants such as wormwoood, the soil is saline to a high degree with many salt lakes and expanses of solonchaks.[1] The soil is light chestnut in colour. Here agriculture without irrigation is possible but not certain.

Deserts :- An arid zone, south of desert- steppe embracing southern Kazakhstan, Turkmenistan, and Uzbekistan stretches from the Volga delta north and east of the Caspian sea to the Persian highlands, then eastwards to Pamir-Tien-Shan mountain complex along the Sino-Russian frontier. The desert region of Soviet Central Asia is uninhabited. In this region evaporation is high and rainfall is very less. Soil of this desert region is more fruitful than regions of higher rainfall, but the lack of water keeps low soil productivity. Along the banks of

[1] Theodore Shabad, 1951 Geography of the U.S.S.R. A regional Survey,, New York. (pp-365-366.)

FIG-2

SOVIET CENTRAL ASIA: PHYSIOGRAPHY



lakes and rivers of these desert parts of the region, there are lush green oases or thicket jungles.

Though the whole of Soviet Central Asia is arid in nature, but Kazakhstan, Uzbekistan and Turkmenistan for account maximum part of their geographical area under deserts and steppes. In Kazakhstan deserts and account for more than 90% of the total area. Similarly Kyzylkum desert, steppes and semi-arid region covers 60% area of Uzbekistan. Other republics have less deserts and steppes land due to the presence of oases and perennial river water.

3. **Plains and Oases** :-

Plains and oases are situated in the river valley of lowlands and the foothills of the mountains. Turanian lowland is the largest low-region in Soviet Central Asia. It streches from the Caspian Sea to the Syr-Darya and the range Kara-Tua in the east and includes the Southern portion of he Ust-Urt Plateau and the two largest deserts of the region; the Kara-Kum and Kyzul-Kum, separated from each other by Amu-Darya. This large plain region is known as the Turanian lowland. In the South and east of Aral Sea, Syr-Darya, Amu-Darya and various other river valley plains are situated a number of big and small oases, such as oasis of Khorezm, Tedzhen and Murgab Oasis etc.

North of the Aral Sea, Turgay lowland is situated which is stripped by sedimentary plain dotted by mesa, butte remnants and sand dunes of high strata. In Kazakhstan plains are situated in southern and western part of republic where Turan lowlands and Caspian lowlands are extending respectively.

In Kyrgyzstan, parts of fertile Fergana valley Oases are situated in the south west and western region, while in the northern area Chu and Talas river plain is situated. In Tajikistan Khodjent part of Fergana valley covers the maximum fertile region.

In Turkmenstan plains are very much localised in the eastern section where Amu-Darya river valley is found. In the Kopet-Dag foothill region and Caspian lowland region, small plains are found.

In Uzbekistan most fertile plain is covered by the Fergana valley, which skirts Syr-Darya and Amu-Darya rivers. These low lands and oases are very fertile and favourable for human settlement.

CLIMATE:-

Climate is a fixed controller of the hydrological cycle, the hydrological cascade of storages and flows in the surface zone and water balance equation of any region depends on the various climatic components like nature and amount of precipitation solar radiation, wind temperature, relative humadity etc. All these factors influence the process of run off, infiltration, transpiration, evaporation and interception of the water resources available in the river basins.

Due to its remoteness from the oceans, the climate of Soviet Central Asia is conventional in nature. The internal seas, the Caspian which borders on Central Asia and the Aral Sea are too small to exert any tempering influence.

In Soviet Central Asia actual temperature in summer is as high as those experienced in Sahara or the interior of Australia. The average summer temperatures vary between 19°c and 32°c but often reach 50° c in the south eastern Kara-Kum in Turkmenistan. The climate in the region is continental, but varies considerably according to altitude. Average winter temperatures vary between -3°c and -20°c but can fall below -45°c in the mountain regions in Tajikistan.

The average annual precipitation in this region is 338mm. varying from less than 70mm in the plains and deserts to 2400mm in the mountains of central Tajikistan.

The climatic characteristics vary among Republics such as in Kazakhstan in the south average temperatures vary from -3°c in January to 35°c in July. In the north, average temperatures vary between -18°c in January and 19°c in July. While records show temperatures of -45°c in January. The frost-free period varies between 195 and 265 days in the south and between 245 and 275 days in the north. The average annual precipitation is estimated at 344mm, ranging from less then 100 mm in the Balkhash - Alakol depression in the central-eastern part of the country or near the Aral Sea in the south, up to 1600 mm in the mountain zone in the east and southeast of the country. About 70-85% of the annual rainfall occurs during the winter season, between October and April. The continental climate is also characterized by its high evaporation level, which together with the low rainfall, makes irrigation a necessity in large parts of the country, notably in the south.

In Kyrgyzstan the frost-free period is 185 days per year in Chu valley, 120-140 days per year in the Fergana Valley. Average temperature in the valleys varies from -18°c in January to 35°c in July. Absolute temperatures vary from -54°c in winter to 43°c in summer. The average annual precipitation is estimated at 533mm, varying from 150mm in the plains (Fergana Valley) to over 1000mm in the mountains. Here precipitation occurs during the winter season, mainly between October and April, when temperatures are low. Here snowfall constitutes an important part of the total precipitation. About 10% of the territory, situated at the lowest altitude is classed as arid.

In Tajikistan, mountain terrain gives rise to wide variations in climate. In those areas where cultivation takes place, which is mainly in the flood plains of the rivers, the climate is of hot, dry summers and mild, warm winters. The average annual precipitation is 691mm, ranging from less then 100mm in the south east up to 2400mm on the Fedchenko glacier in the central part of the country. Here precipitation also occurs during the winter season, mainly between September and April. The average temperature is about 16°-17°c.

The absolute maximum temperature recorded is 48°c in July, the absolute minimum temperature is 49°c in January. The daily temperature range is about 7°c in winter and 18°c in summer.

In Turkmenistan climate is subtropical desertic. The average annual precipitation is about 191mm, ranging from less then 80mm in the northeast to 300mm in the Kopetdag mountain zone in the southwest. Precipitation occurs during the winter season, mainly between October and April. The average temperature in January is about -4°c in most of the republic, except in the southwest where the climate is milder with an average temperature exceed 30°c throughout the country.

In Uzbekistan over 60% area is characterised by arid/desertic type of climate. The averge annual rainfall is 264mm, ranging from less then 97mm in northwest to 425mm in the mountainous zone in the middle and southern parts of the country. In the Fergana valley, the average annual rainfall varies between 98 and 502mm, while in the Tashkent Vilayat, it varies between 295mm and 878mm.

Rainfall occurs during the winter season, mainly between October and April. The climate is characterized by high temperatures in summer (42-47°c in the plains and 25-31°c in mountainous zone in July) and low temperatures in winter (-11°c in the north and 2-3°c in the south in January). Frequent frost occurs between late September and April.

The whole Central Asian region has continental climate where evaporation exceeds precipitation and the region is arid or semi-arid. Drought is the unifying factor of Soviet Central Asia. Only the Syr-Darya and Amu-Darya which are fed by melting snow and ice from the mountains, survive the journey through the deserts to the Aral Sea.

Following data shows the temperature distribution in Soviet Central

Asia:-

Table - 2

TEMPERATURE DISTRIBUTION IN SOVIET CENTRAL ASIA IN (°C)

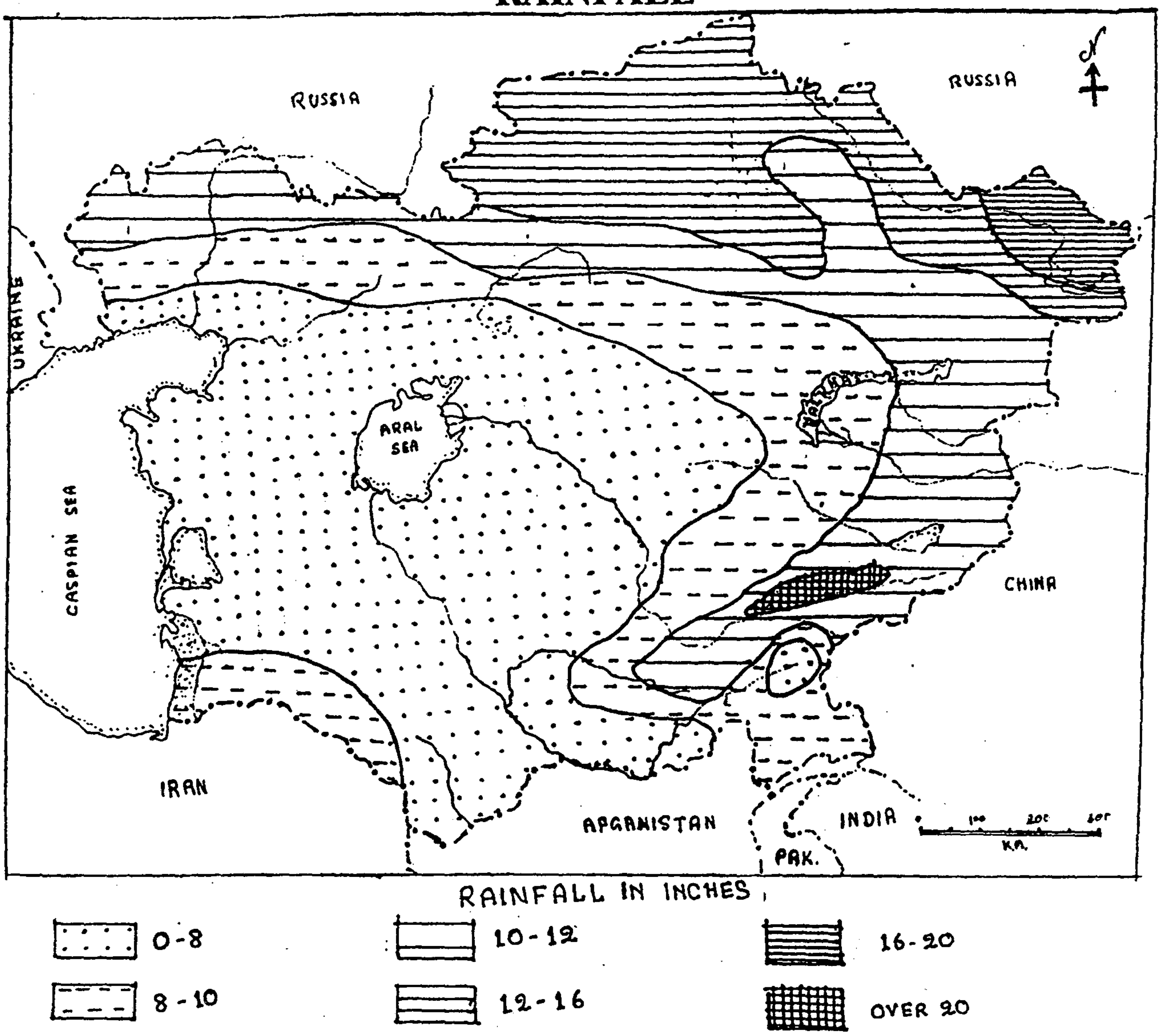
Republics	Summer Temperature in July (In °C)		Winter temp. in January (In°C)	
	Maximum	Minimum	Maximum	Minimum
Kazakhstan	30	19	-3	-45
Kyrgyzstan	43	28	-18	-54
Tajikistan	48	16	-12	-49
Turkmenistan	48	14	8	-4
Uzbekistan	47	25	3	-11

Source : A Geography of the Soviet Union, by John C. Dewdney, Oxford, -1971 (pp-36-38).

For greater understanding the map of annual precipitation in Soviet Central Asia has been given below. From this map one can safely conclude that the eastern and north-eastern part of the region is also inclined towards east to west and in the northern portion of Kazakhstan towards north.

FIG - 3.

SOVIET CENTRAL ASIA : AVERAGE ANNUAL RAINFALL



NATURAL VEGETATION:-

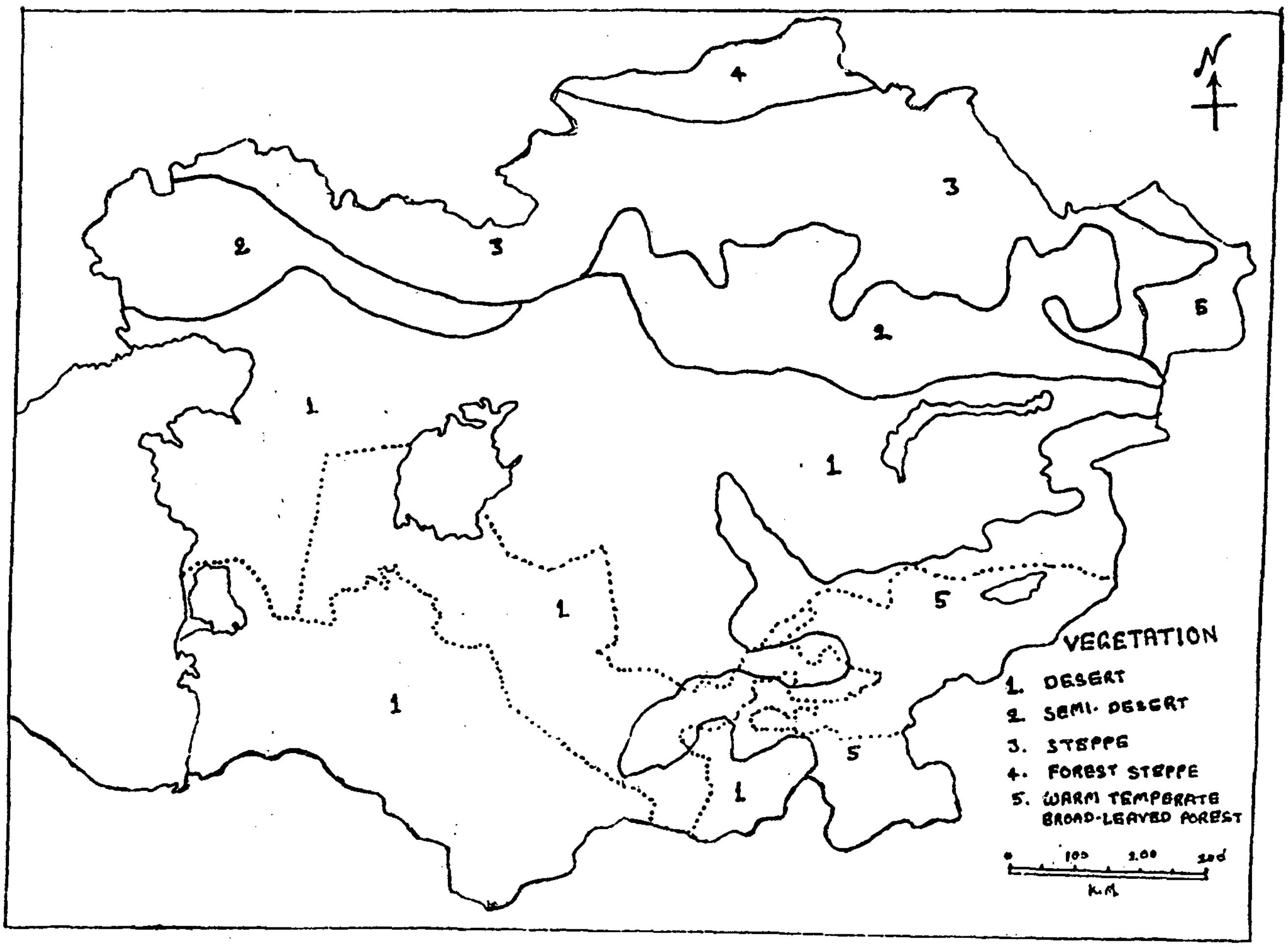
Vegetation plays major role to influence the hydrological cycle. It produces a different effect on precipitation, volumes of evaporation and its umbrella like shape has an influence on rainfall and a generally protective outcome has been always assumed for river behaviour. Forests slow down the run-off and thus check soil erosion and intensity of floods. Its species type, density, stem characteristics, debris and roof characteristics influence the interception, infiltration, transpiration process of the hydrological cycle.

The dry and extremely continental climate exerts a strong influence on the vegetation of Central Asia. Plants which adopt to withstand drought periods are predominant in the desert and in the mountains. Steppe vegetation covers not only the plain but also the mountain slopes, reaching even to the area of permanent snows. In the high mountain valleys of the Tien Shan and the Pamir area, salt steppes and salt lakes, only a portion of the mountains generally the northern and western slopes is wooded. Wooded belts also occur along some rivers.

The desert vegetation consists of rather poor varieties. In the sandy desert, the saksaul tree is the predominant type. Of the other plants umbrella-shaped plants, among which the Asafetids Giant fennel, exuding an ill smelling regionous substance and desert shrubs with large meaty leaves are the most common. The long roots of the

FIG - 4

SOVIET CENTRAL ASIA : NATURAL VEGETATION



desert plants immobilize the sand, so that moving sand dunes are found only where no vegetation normally exists or where it has been destroyed by irrational grazing of livestock. Among the sands, occasional clay flates are covered sparsely by various types of wormwood and camelthorn and saltwort is found in salt depressions. Along the rivers and the salt lakes are thickest of Chiy, a feather grass often reaching a height of 12 feet.

The mountain forests include deciduous trees on the lower slopes with wild growing walnut, pistachio etc. common European types, such as pine, oak and linden are completely lacking. In the eastern Tienshan a type of fir is found. Above the forest zone there are rich mountain pastures, similar to Alpine meadows in the humid areas and to the Caspian steppe in the driver sections.

Thus the nature of the vegetation cover of Soviet Central Asia shows the regimen or the amount and intensity of rainfall, habit of streams and water resource availability of the region. The dense and high green forest represents the surplus water region and the scattered bushes represent water deficit zone, while the grass land represents the medium water zone.

SOIL :-

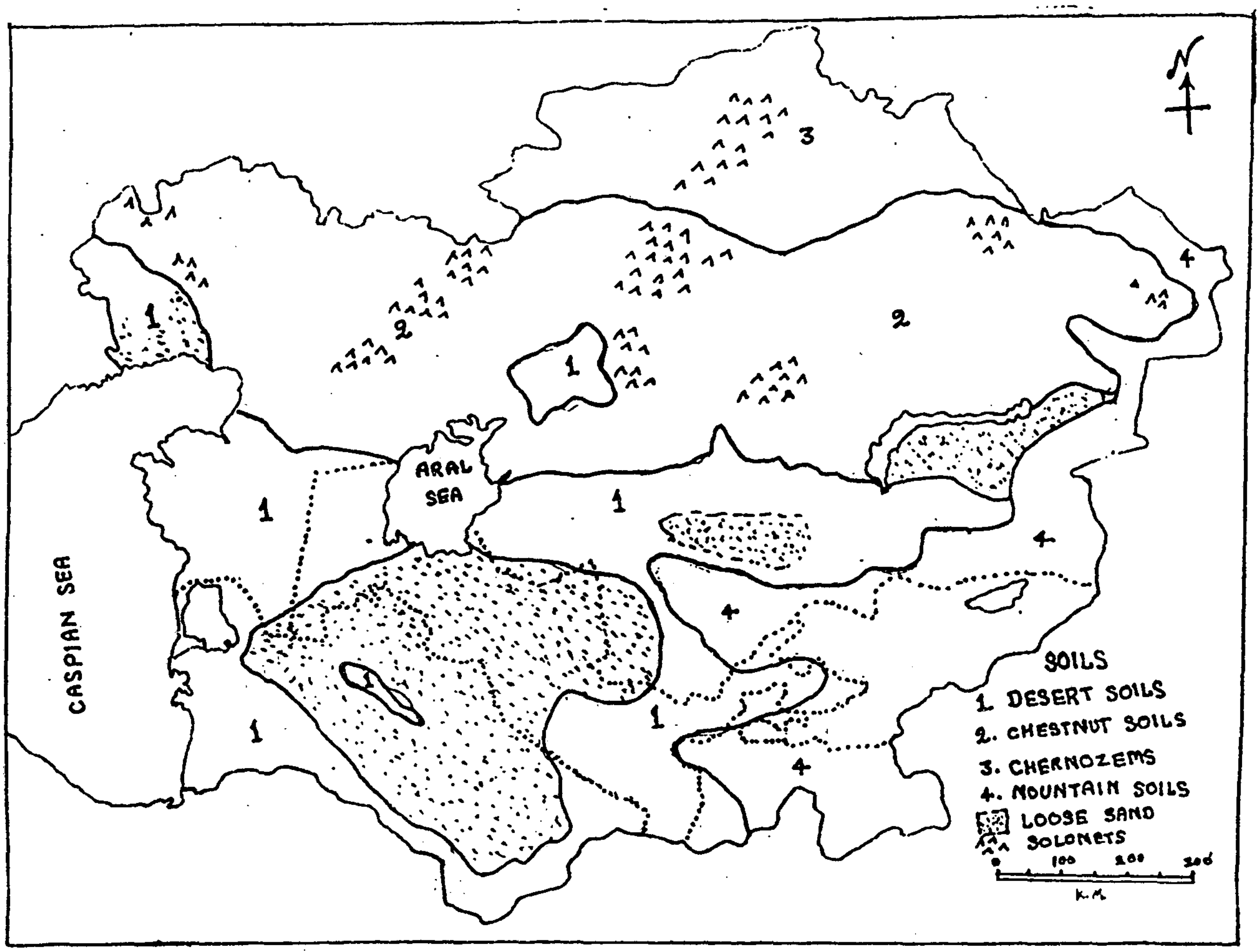
Soil influences the quantity and quality of groundwater. It also determines the spatial pattern of runoff processes and strengthens the validity of the soil. The moisture content, particle size distribution, pore space characteristics, organic matter content and temperature of the soil influence the infiltration, evaporation, interflow, capillary flow, gravitational flow, capillary rise and roof absorption processes of the hydrological cycle in any region.

The homogenous character of the relief over most of the area in the region and dominant fluvio-aeolian activities with synonymous climatic conditions is characteristic of the whole region. Soil character of Central Asia lacks any marked variation from one region to another. Inspite of the homogeneity in climate and relief with some variations due to presence of mountains in the eastern and south-eastern margin and latitudinal expansion of the region have caused differences in the soil forming process. In the western and southern part of the region due to higher temperature and lesser rainfall (where potential evepo-transpiration is more than precipitation) the soil is sandy and alkaline in nature with a poor and thin vegetation cover. This soil is primitive in nature. Due to water action, modification of thin upper layer can be seen. The productivity, therefore is very low. In this sandy soil the pore spaces are large, so the water retention capacity of the soil is very poor and water drains rapidly.

In the northern part of Soviet Central Asia and north east part of the Caspian sea region, Chernozem soil is dominating. While in the central and north western part of the region where range of temperature is higher with very low temperature in winter,

FIG - 5

SOVIET CENTRAL ASIA : SOILS



Chernozem is replaced by chestnut soil. The whole eastern and southeast part of the region is dominated by the mountain soil.

AGRICULTURE AND URBAN INDUSTRIALISATION :-

Economic activities and level of economic development of any geographical area determines the consumption pattern and way of management of water resources. Demand of water resources is a function of economic structure such as primary, secondary, tertiary and quarternary etc. and user's income and price of water.

Soviet Central Asia is characterised by primary activities such as agriculture and secondary urban industrialization and other manufacturing activities. Agriculture and urban industrialization is major water consuming sector in the region.

AGRICULTURE:-

Agriculture of Soviet Central Asia can be characterised broadly into three types :

(i) Extensive grazing

(ii) Dry farming

(iii) Intensive irrigation farming

(i) **Extensive grazing** :-

Some grazing of livestock is carried on nearly everywhere, but it becomes the predominant economy in the drier lowlands and in the mountains where cultivation is largely impossible. The entire lowland from the Caspian sea to the eastern end of lake Balkhash and extending to the southern border of Turkmen Repblic, except for scattered regions of irrigation is utilized only for grazing. Sheep and camels predominate in the lowland deserts. Cattle, sheep and goats utilize the desert pastures in winter and spring but must be driven to the mountains during the summer. Transhumance is practiced on a grand scale.

(ii) **Dry Farming** :-

Wheat and some other grains are dry farmed in the moister portions of

the loess- covered foothills in the south where precipitation averages between 10 and 15 inches per year. In these area rain comes primarily in late winter and early spring, which is quite advantageous for wheat growing. Dry farming of grain has been carried on in the loessial foothills for a long time, but under the virgin lands program additional areas have been opened up.

(iii) **Intensive irrigation farming** :-

Wherever irrigation water and good soil is available, intensive irrigation farming of cotton, alfafa, some grain and many vegetables and fruits are grown. This type of farming has been practised mainly in major oasis and river basins since long historical period till the present era. These river basins are : Zeravshan river basin, Fargana basin, southwestern area of Tajikistan which utilizes the water of Vaksh river, Tashkent area utilizing the water of the Chirchik and

Angren river. The largest area of this type of agriculture is in Amu-Darya and Syr-Darya river Basins.

This type of irrigated agricultural development was shaped during the periods of Tsarist occupation, before the emergence of Soviet Union. But during the Soviet period, this type of agriculture practice was extended to a wider area under increasing awareness among the local people and due to conversion of vast virgin plane land and pasture land into agriculture areas.

After the second world war irrigated farmland had in creased in whole of Soviet Central Asia in revolutionary way. In 1950, in Uzbekistan the irrigated farmland was 2276 thousand hectares. It increased to 3132 thousand hect. in 1976. Similarly Turkmenistan had 454 thousand hect. of irrigated farmland in 1950, which increased to 846 thousand hectare in 1976. The following table shows this :-

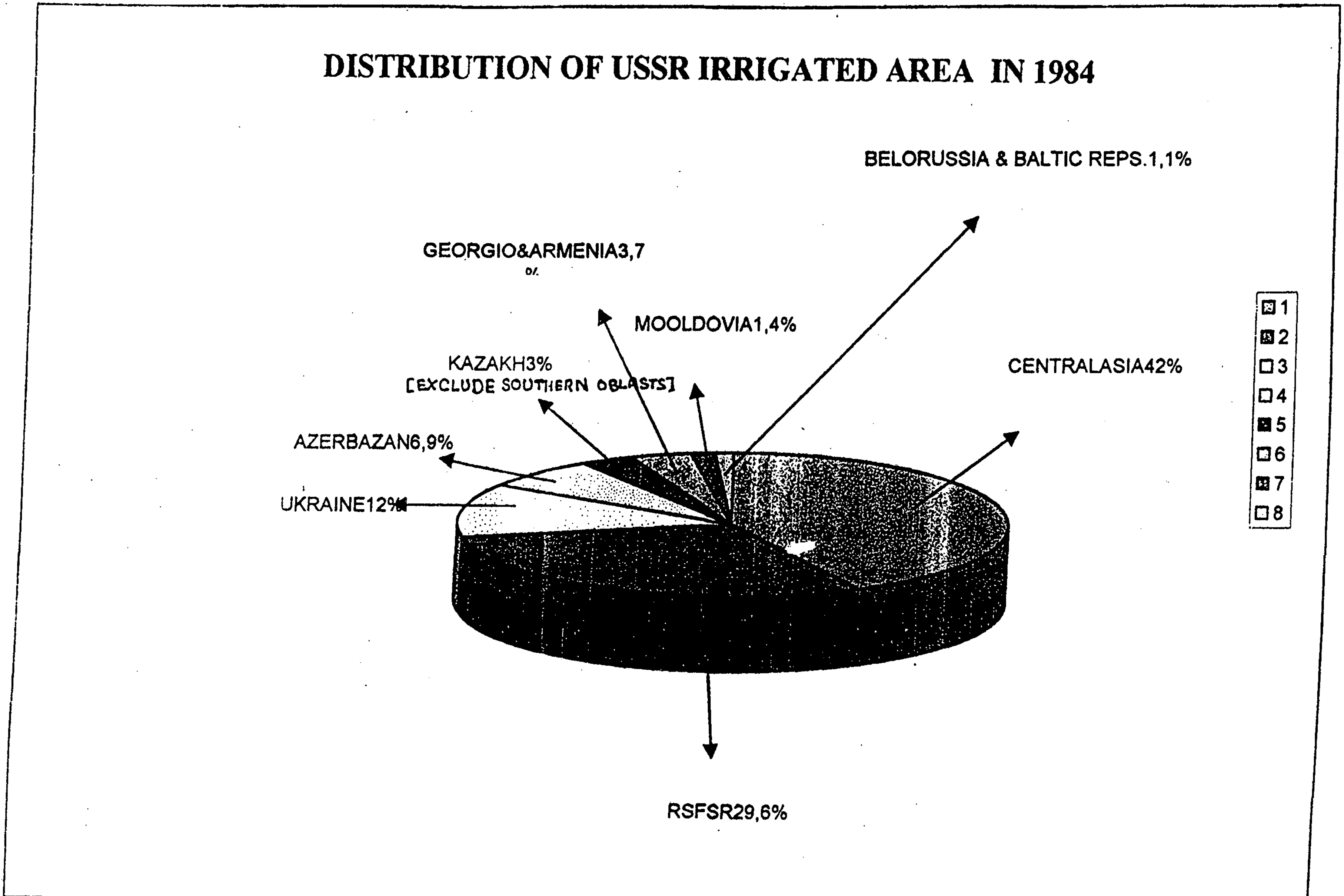
Table - 3

AREA OF IRRIGATED FARM LAND BY REPUBLICS IN SOVIET CENTRA ASIA (thousand of hect.)

Republics	1950	1960	1965	1968	1970	1971	1972	1973	1974	1975	1976
Uzbekistan	2276	2571	2639	2666	2697	2721	2774	2915	2915	3006	3132
Kazakhstan	1393	1466	1368	1265	1450	1479	1509	1601	1601	1648	1707
Kyrgyzstan	937	929	861	869	883	891	897	904	904	911	924
Tajikistan	361	427	468	506	518	528	535	552	552	567	582
Turkmenistan	454	496	514	543	943	672	698	796	796	819	846
Total	5421	5889	5850	5849	6191	6291	6413	6768	6768	6851	7191

Source : Computed from data in Selskoye 1988.

FIG-6



SOURCE:- NARODNOYE KHOZYABSTVOSSSR V 1984, P.273; NARODNOYE KHOZYAYSTVO KAZAKHS; ANAV. 1984 P.98

Till 1980s Soviet Central Asia (with 42%) had the highest % of irrigated farmland in whole of former Soviet Union. The Pie-diagram shows it clear.

In the irrigated farming, cotton was predominant crop. It was grown on 61% and 59% irrigated farmland area of Uzbekistan and Tajikistan respectively. Only in Kazakhstan and Kyrgyzstan grains and fodder crops were grown on large % of irrigated farmland. This trend can be seen in the table given below.

Table - 4

CROPS SOWN ON IRRIGATED FARMLAND IN SOVIET CENTRAL ASIA IN 1994 (Millions of hectares)

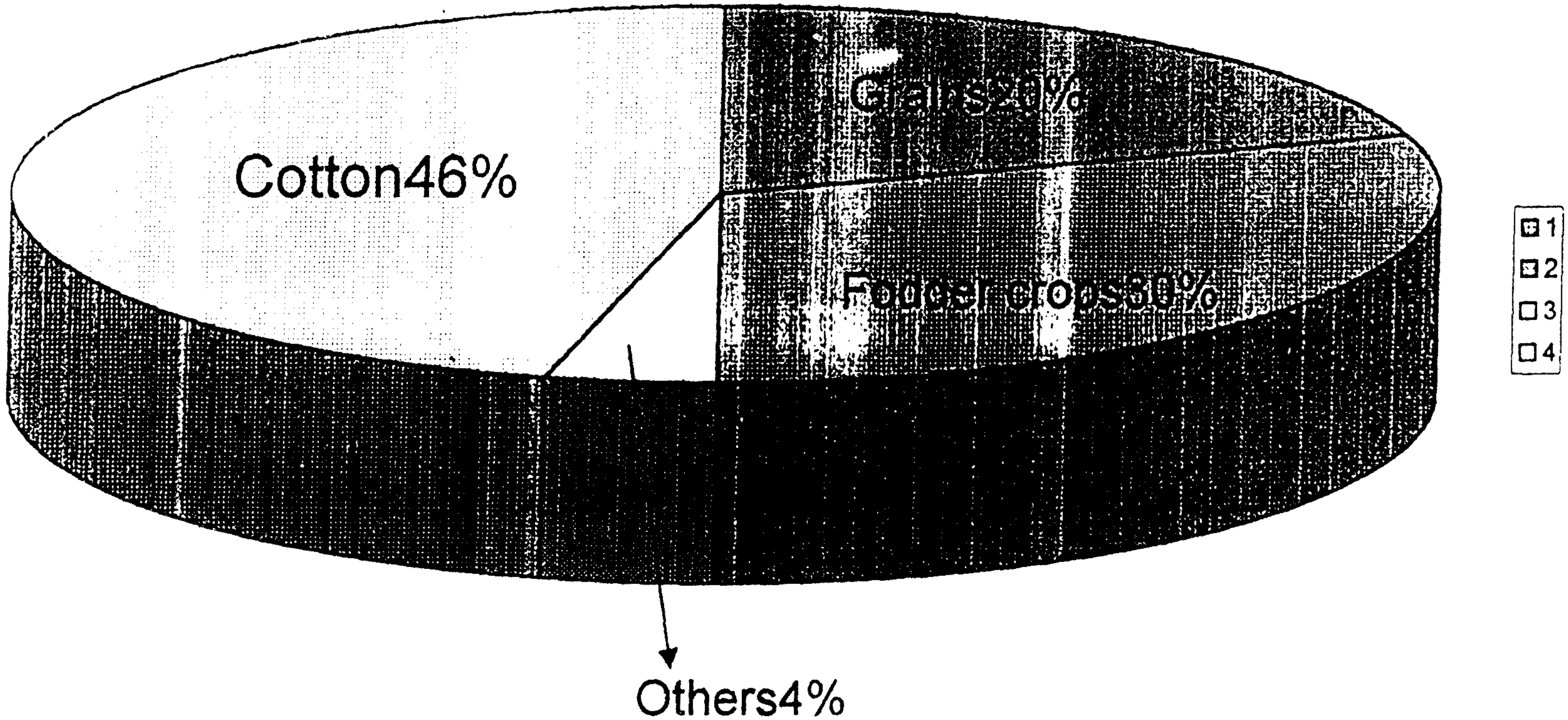
Republics	Sown area	Grains	% Sown area	Cotton	% Sown area	Potatoes vegetables melons	% Sown area	Fodder crops	% Sown area
Uzbekistan	3.316	0.446	13.44	2.053	61.90	0.132	3.98	0.686	20.68
Tajikistan	0.531	0.056	10.63	0.313	58.98	0.021	4.06	0.140	26.23
Kirgyzstan	0.865	0.251	13.44	0.089	10.79	0.029	3.53	0.456	55.25
Turkmenstan	0.983	0.139	14.10	0.546	55.46	0.042	4.23	0.258	26.21
Kazakhstan (Southern ablast)	1.247	0.471	34.97	0.235	17.49	0.059	4.38	0.581	43.16
Total	7.113	1.363	19.46	3.236	46.21	0.283	4.05	2.120	30.28

Source : narodnoye Kjhozyaysto Kazakhstvo SSSR v. 1984, p. 274 Narodnoye Khozyasto Kazakhstana v. 1984 .99.

Thus in the whole Soviet Central Asian region cotton was grown on 46% of irrigated farmland area while fodder crops covered 30% and grains 20% land area respectively. The Pie diagram shows this trend clearly.

Figure- 7

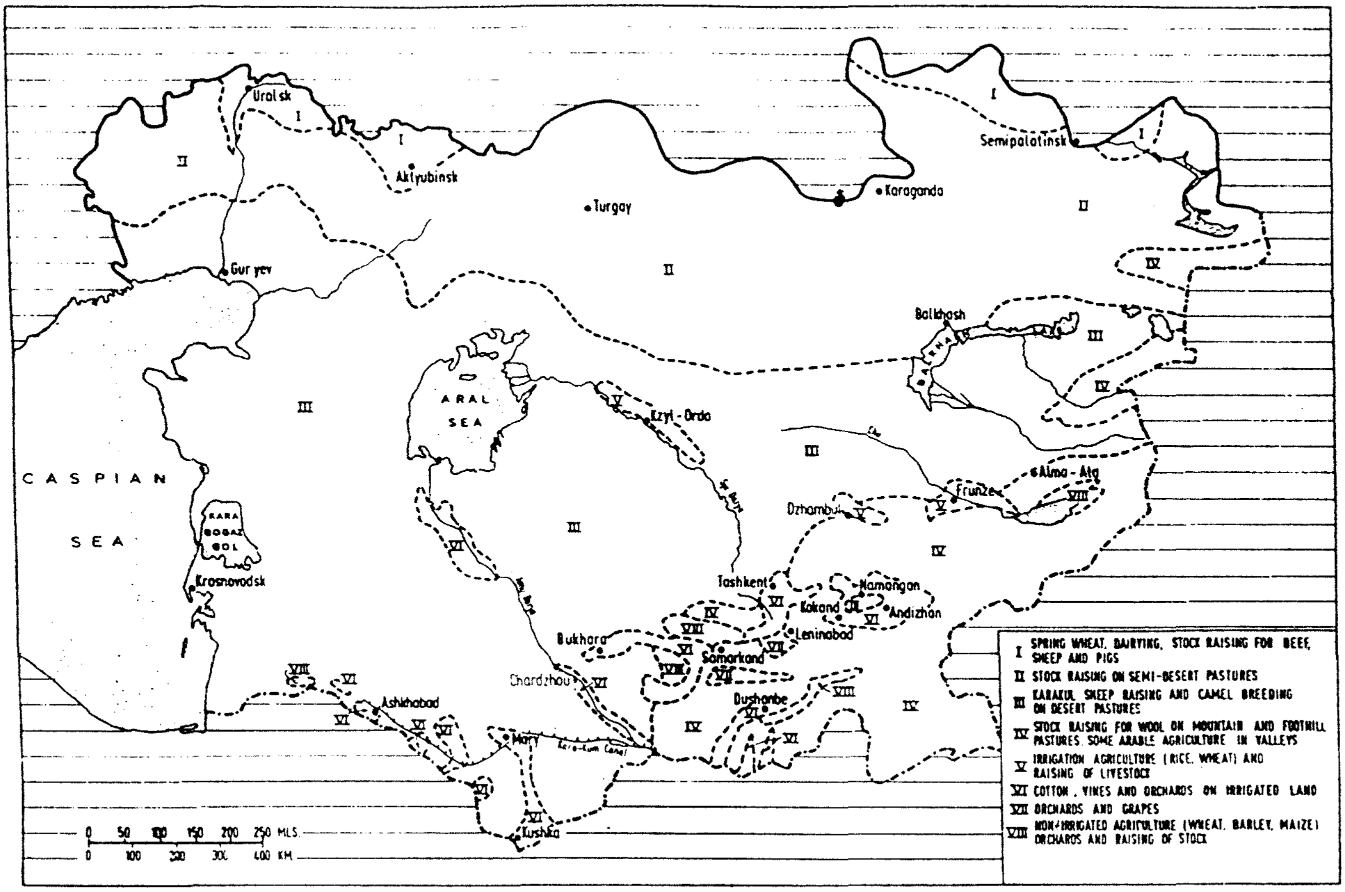
IRRIGATED CROP SOWINGS IN CENTRAL ASIA



Source:Table 4

FIG - 8

SOVIET CENTRAL ASIA: AGRICULTURAL LAND USE REGION



URBAN INDUSTRIALIZATION:-

With the development of transportation facilities, oil and gas pipelines, the digging of irrigation canals, construction of hydro-electricity stations and exploitation of natural wealth, urban industrial development increased in Soviet Central Asia. This region is not known for heavy industrialization. The main industries are cotton textile, based on locally produced cotton crop, some machine building industries and light industries. Fertilizers, nitrogen and other chemicals are produced where natural gas is found. Navio complex (Turkmenistan) is a major chemical centre. Hydroelectricity is produced in the small valley basics. Some hydroelectric sites are Toktagul (Naryn river) in Kyrgyzstan with 30 billion K.W. Chirchuk river has a capacity of 330, 600K.W. but in 1980s a new unit at this place with a capacity of 600,000 K.W. was installed Amu-Darya has capacity of producing 100,000 K.W.

After 1960s, urban industrialization increased in the region, which created more stress on water resources available there. Major urban industrial centres are.

Tashkent :-

It is the capital of Uabekistan. It lies on the historical silk route. Here textile is the major industry followed by machine building industry and other foot loose industries, In 1967 it had a population of 1,239,000, which became 1,600,000 in 1989.

Frunze (Bishkek):-

It is the capital of Kyrghyzstan, situated on the headwaters of Chu river on the northern slopes of Tienshan. Here machine building, textiles and food processing are the main industries. It had 396,000 population in 1967 which increased upto 800,000 in 1989.

Dushanbe :-

It is the capital city of Tajikistan, situated on the southern side of Gissar range (of Tienshan) in the south-western part of the country. Here textile mills, machine building and food processing are the major industries. This urban industrial centre had a population of 333,000 in 1967 which increased to 750,000 in 1989.

Samarkand :-

It is situated in Uzbekistan on Zeravshan river. Here textile is the main industry. It had 248,000 population in 1967 which increased upto 300,000 in 1989. This urban industrial zone shows slow growth.

Ashkhabad :-

It is the capital city of Turkmenistan, situated on the southern adge of Kara Kum desert. This city is connected with trans-Caspian railroad. Textile and machine building factories are the major industry of this city. Population growth of this urban industrial centre is also slow. It had a population of 238,000 in 1967 which increased upto 300,000 in 1989.

Alma-Aty :-

It was the capital of Kazakhstan. It is nestled in the foothills of the Tienshan in the south-east of the country. The small streams flowing down from the snow-capped mountains in the south criss-cross the surrounding area with their fans and move to desert and lake Balkash in north. It has machine building and light industries. It had a population of 652,000 in 1967, which increased upto 15,10,000 in 1989.

Population growth of urban industrial centres can be seen in the table given below:-

Table - 5

URBAN POPULATION GROWTH OF MAJOR INDUSTRIA CITIES IN SOVIET CENTRAL ASIA

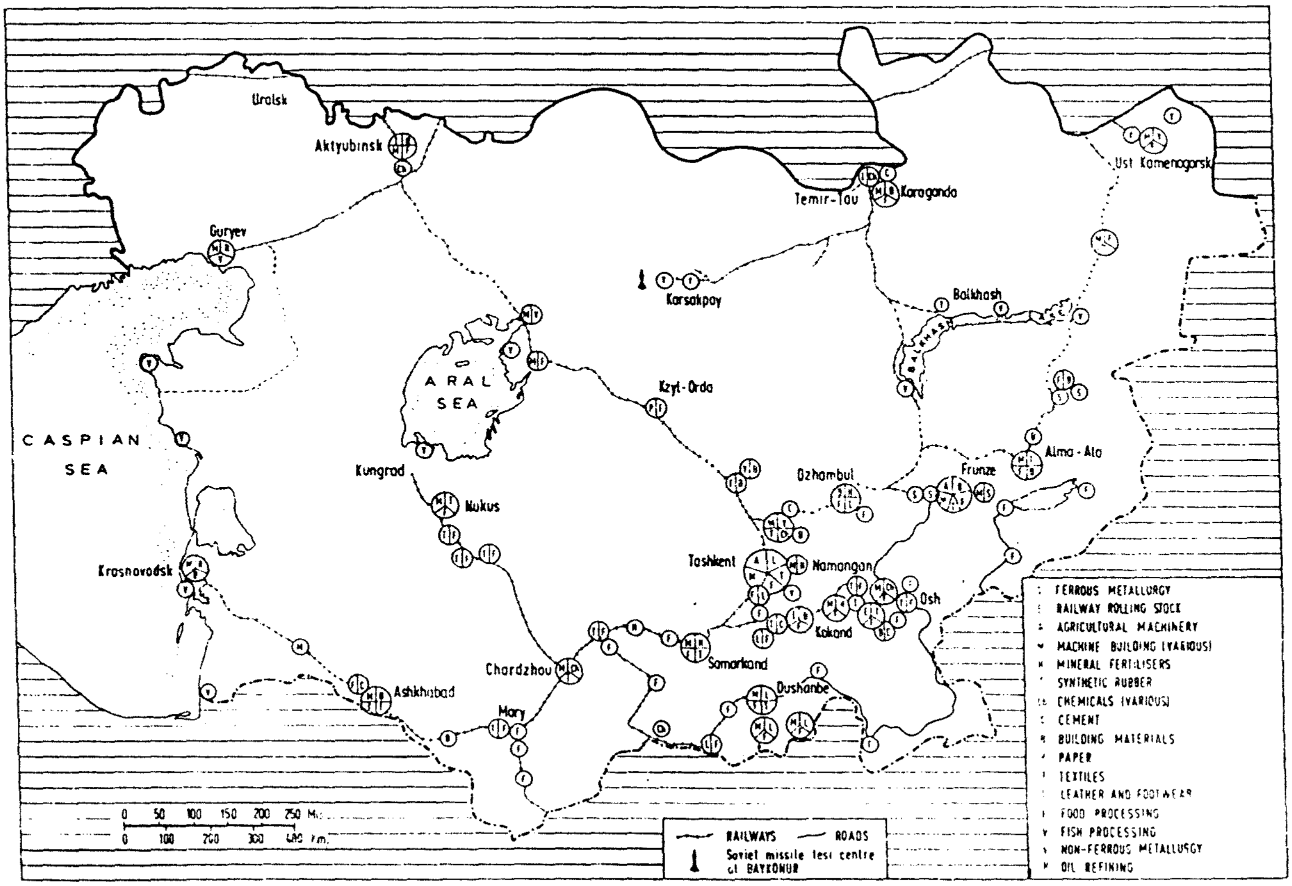
Industrial Cities	Population in 1967	Population in 1989
Tashkent	1,239,000	1,600,00
Frunze (Bishkek)	396,000	800,000
Dushambe	333,000	750,000
Samarkand	248,000	300,000
Ashkhabad	238,000	300,000
Alma-Ata	652,000	1,510,000

Source : World Regional Geography by R.N.Tikha Jalandhar. India - 1998 (pp. 681-692), Geography of the U.S.S.R. by Paul E. Lydolph New York - 1964 (pp. 258-261).

Apart from these major centres, there are a number of other urban industrial centres such as Merv, Krasnovodsk, Kzylorda, Balkhash etc. dominated by cement, paper, oil refining, fertilizer, railway building industries. The map shows the urban industrial structure of the region.

FIG - 9

SOVIET CENTRAL ASIA: URBAN INDUSTRIAL STRUCTURE



HUMAN RESOURCE:-

Humans are a major determinant of the hydrological process. The nature and amount of water resource use and supply is governed by the quality, number and lifestyle of human beings. The growth of population and change of their economic activities are creating stresses on natural water cycle. The alarming rate of population growth in urban and also in the rural areas are creating pressure on the demand of natural resource, especially water has increased considerably. In the developing countries due to population the removal of natural vegetation and wetlands for agricultural land and the encroachment of building and structures towards the channel, human beings are creating a negative impact on water cycle. "In the former USSR as a whole impact of urbanisation on annual precipitation large industrial cities area generally 5-10% higher for particular storms. Complete urbanisation of watershed in former USSR increased the mean flood discharge by 5 to 10 times. Urban development also affected the underlying aquifer systems in the form of reduced infiltration and consequently less groundwater recharge followed by lowering by ground water levels. Also owing to extensive use of groundwater. Also, the domestic and industrial wastes disposed on ground which lead to degradation surface and ground water quality."[2]

Land locked and water deficit region of world, Soviet Central Asia is a single region historically, ethnically, economically, socially and politically endowed with special features. Human resource is important to determine the level of economic development and water resource use in the region. It depends upon man how to interact with our environment. The general direction of our development is largely influenced by the opportunities offered by the nature. It provides the broad framework of development.

In Soviet Central Asia population growth has taken place rapidly. In 1959 it had 27,977,000 people which increased upto 32,804,000 in 1970 and the region had 54,588,000 people in 1996. The distribution of population is very uneven, major concentration of people found near and around the river valleys and irrigated areas. Farghana valley has the greatest concentration of population. Further the urbanisation process is also increasing year by year. In 1959 Soviet Central Asia had 79.4% rural population and 20.4%. In 1970 the rural population % decreased and urban population increased during this period. In 1970 rural population was 58.2% and urban

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[2] Sustainable Management of Natural resources Eds. T.N. Khoshoo & Manju Sharma, under the auspicies of National academy of Sciences Indian Allahbad (pp. 49-69).

was 41.8%. At present about 44% population live in urban area and 56% population live in rural areas.

Thus the increasing urban population growth as well overall total population growth of Soviet Central Asia created excess pressure on limited water resource. Trends of population growth in the region can be seen in the following table.

Table - 6
TREN OF POPULATION GROWHT IN SOVIET CENTRAL ASIA

Republics	Population in 1959			Population 1970			Population in 1996		
	Total	Rural %	Urban %	Total	Rural %	Urban %	Total	Rural %	Urban
Kazakhstan	9,153,000	76	24	12,850,000	49%	51	16,820,000	40	60
Uzbekis-tan	8,261,000	78	22	11,963,000	64	36	23,209,00	58	42
Tajikistan	1,981,000	79	21	2,900,00	63	37	5,935,000	68	32
Kyrgyzs-tan	2,066,000	89	11	2,933,000	63	37	4,469,000	61	32
Turkmen-istan	1,516,000	75	25	2,158,000	52	48	4,155,000	55	45
Total	22,977,000	79.4%	20.6%	32,804,000	58.2%	418%	54,588,000	56.4%	43.6%

Sources :- New direction in the Soviet economy (p. 644) world development report 1997,World Bank.

Literacy rate shows the advance of the human kind in any society which is positively corelated with the level of interaction of human beings and their available resources. Soviet Central Asia has almost cent percent literacy rate.

Table - 7
LITERACY IN SOVIET CENTRAL ASIA

Republics	Literacy in (%) in 1985
Kazakhstan	99
Uzbekistan	99
Tajikistan	99
Kyrgyzstan	99
Turkmenistan	99
Total	99%

Source : World development report 1987 world bank.

Primary sector dominates in the economic structure in the whole region. More than 40% population is engaged in agriculture, except in Kazakhstan where tertiary sector dominates. So the work force structure gives us an insight into the importance of agriculture and the pressure on water resource in Soviet Central Asia. The fast increasing population exerts further strain on already highly exploited land for agriculture and water resources in the region.

Thus the overall geographical background of the region provides the base for sectoral water availability and usage which makes the water management prospects more clear.

CHAPTER - II

SECTORAL AVAILABILITY AND USE OF THE WATER RESOURCE

It is usual to consider water resources as that part of the water cycle which accounts for the passage of water through the lithosphere and troposphere. Aquatic ecosystems exist wherever water is concentrated in this cycle in lakes, rivers, marshes, oceans, soil moisture and ground water.

Though the amount of water on and close to the earth surface is vast but most of it is in the ocean and only a small fraction of fresh water is stored in the polar ice caps in glaciers and in ground water. Thus only a very small quantity is readily available for human use. Essentially this is the water lying in the world's rivers and lakes. This variable in the concentration of earth's water resource is reflected the in the following data.

Table - 8

SECTORAL AVAILABILITY OF EARTH'S WATER RESOURCES

CATEGORY	TOTAL VOLUME (km^3)	% OF TOTAL	% OF FRESH WATER
i)World Oceans	1,338,000,000	96.5%	_
ii)Ground Water (to 2,000m)	23,400,000	1.7%	_
iii)Predominantly fresh ground water	10,530,000	0.76	30.1
iv)Soil Moisture	16,500	0.001	0.05
v)Glaciers and Permanent+Snow	24, 064, 100	1.74	68.7
- Antarctica	21, 600, 000	1.56	61.7
- Greenland	2, 340, 000	.17	6.68
- Arctic islands	83, 500	.006	.24
- Mountain areas	40,600	.003	.12

vi)Ground ice (parmafrost)	300,000	.022	.86
vii)Lakes - Fresh water - Salt water	176,400 91,000 85,400	.013 .007 006	 .26 -
viii) Marshes	11,470	.0008	.03
ix) Rivers	2,120	.0002	.006
x)Biological water	1,120	.0001	.003
xi)Atmospheric water	12,900	.001	.04
Total	1,385,984,610	100%	
Fresh water	25,029210	2.53	100%

Source :- Companion Encyclopedia of Geography - The Environment and Humankind T.J. press, 1996, London (pp - 526).

In global water resource fresh water is just 2.53%. In a sense, this fresh water ecosystem is a natural machine, a constantly running distillation and pumping system. The sun injects thermal energy, which together with gravity, keeps water moving. Although this water cycle has no beginning or end, oceans are the major source, atmosphere is the delivery agent and land is the user. In this system, no water is lost or gained. But the amount of water available to the user may fluctuate on account of variation in either the source or more usually the delivery agent. Large fluctuations in the atmospheric evaporation, condensation and precipitation can produce deserts, floods, drought and snow in any region of the globe. In the natural water cycle about one fourth of the total precipitation forms surface water bodies, out of which more than half enriches the soil moisture and ground water. Whereas the rest is evaporated back into the atmosphere in the tropical countries.

But in case of land locked subtropical Central Asia where continental climate is dominating and creating very variable annual weather condition, the average annual rainfall is just 25 to 50cm which is very less than the required water for the balanced circulation of the surface water. However, Central Asia though dominated by deserts, has been known for its lush green and fertile oases which has been due to availability of water. Wherever there has been water in the form of rivers, streams or lakes, the area has turned into green oasis full of life and habitation.

But the quantum of water usage in the region has been increasing due to rapid growth of population and spurt in industrial urbanisation in the region. Though the region has number of big and small river, lakes, ground water, snow and various other sources, water availability is more easy in upstream countries of Kyrgyzstan and Tajikistan and source in down-stream countries of Uzbekistan, Kazakhstan and Turkenistan.

SECTORAL AVAILABILTY OF WATER RESOURCE

Continental climatic location of Soviet Central Asia creates complexity in the sources of actual and internal renewable water resources in the region. The chief sources of water can be categorised as under:

Surface water:-

1. Annual Precipitation
2. Rivers
3. Lakes
4. Reservoirs, glaciers.
5. Ground water and various other sources.

ANNUAL PRECIPITAITON :-

The atmosphere acquires moisture by evaporation from oceans, lakes rivers and damp soil and transpiration from plants in processes referred to as "evapotranspiration" and precipitation may then occur. During precipitaiton some evaporation occurs in the air but much of the water reaches the ground surface or vegetation. Some water is held by plant canopy and eventually evaporates again and some will run down, drip from the canopy or be shaken off by the wind and eventually reach the ground. Of the water that reaches the ground some will infiltrate the surface, some will accumulate in surface depressions, some will begin to move over the surface and some may percolate through deeper layers and enter the ground water system where it may be held for long periods.

The average annual precipitation in Soviet Central Asia is 338 mm or 1351 km^3. Out of total precipitation of former Soviet Union

(F.S.U.), Central Asia has about 11.1% of precipitation, which is just 1.2% of precipitation in the world. The distribution of precipitation is varying in plains, deserts and mountainous areas. For example plains and deserts receive less than 70 mm while the mountains of Tajikistan and Kyrgyzstan receive 2400 mm of precipitation. This variation in precipitation is also found in all the five republics of Soviet Central Asia.

Following data shows the variable distribution of precipitation within the five Central Asian Republics.

Table - 9

DISTRIBUTION OF ANNUAL AVERAGE PRECIPITATION IN SOVIET CENTRAL ASIA

Republics	ANNUAL AVERAGE PRECIPITAION		% OF WHOLE REGION
	MM.	Million m^3	
1) Kazakhstan	344	934751	69.2
2) Kyrgyzstan	533	105801	7.83
3) Tajikistan	691	98882	7.32
4) Turkmenistan	191	93227	6.90
5) Uzbekistan	364	118114	8.74
Total	338	1350775	100%

Source :- Water Report of the former Soviet Union (F.A.O.) of United Nations. Rome, 1997.

Kazakhstan has the highest volume of water that is about 934751 million M^3. This is due to largest physical area of the Republic in the whole region. Though Tajikistan has less % of rainwater, it has the highest volume of annual average rainfall in the whole of Central Asia.

Further the % of precipitation in annual internal renewable water resource in the region is very limited and unevenly distributed. The trend becomes clear in the following data.

Table - 10

% OF PRECIPITATION IN ANNUAL INTERNAL RENEWABLE WATER RESOURCES

REPUBLIC	ANNUAL AVERAGE PRECIPITATION	ANNUAL RENEWANBLE WATER RESOURCE INTERNAL		
	(million m^3)	Million M^3	M^3 per inhabitance	% of precipitation
1)Kazakhstan	934751	75420	4484	8.06
2)Kyrgyzstan	105801	464450	10394	44
3)Tajikistan	98882	66300	11171	67
4)Turkmenistan	93227	1360	327	1045
5)Uzbekistan	118114	16340	704	14
Total	1350775	205870	27080	15.24

Source :- Water Report of the former Soviet union (F.A.O.) of U.N. Rome - 1997.

Tajikistan has the highest % (67%) of precipitation in annual internal renewable water, followed by Kyrgyzstan (44%). Turkmenistan has just only (1.47%), which is the lowest % of precipitation in the region. In the whole region the average % of precipitation in annual internal renewable water resource is only 15.24%.

Thus due to very limited supply of water through precipitation there is a complex interrelation between surface water and the ground water in the former Soviet Central Asia. In this harsh situation only perennial rivers originating from the snowy mountain peaks are the permanent source of water in the region.

Rivers as the Major Source of water

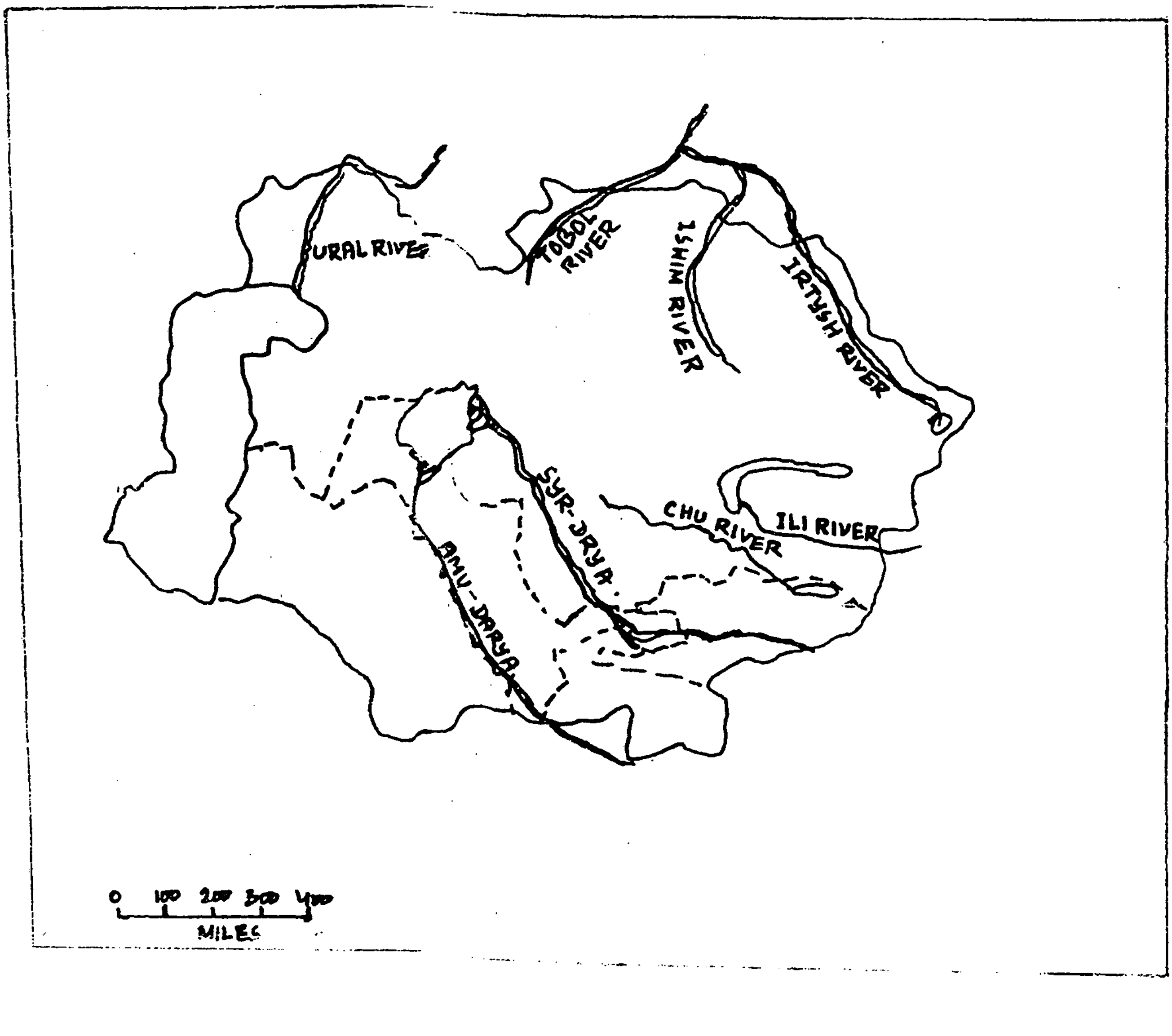
One of the most arid zone of the world, Central Asia has a number of big and small rivers. None of them flows into the open sea; they either vanish into the sands or finish their courses in lakes, some of which are so small that they dry up in summer. From the point where the rivers descend to the plains, they also lose much of their water in irrigation and evaporation. The amount of water in the rivers is controlled by the snows and glaciers in the mountains, so that the bigger rivers carry an increased amount of water twice a year, at the beginning of summer when the low lying snows dissolve and in the middle of summer, sometimes as late as August, when the eternal snows and glaciers lying in the mountains melt.

The main river basins of the region are - Amu Darya, Syr-Darya, Irtish, Chu, Talas, Assa, Turgay, Naryan and number of other small rivers. Rivers flowing from the Kopet-Dag have a different regimen. Since they collect their water from less high mountains without eternal snow they depend on seasonal rains and reach their maximum level in spring, i.e. the rainy season coinciding with the melting of snow on the slopes. Eventually they disappear into the sands, except some rivers like Atrek which manages to reach the Caspian.

Most important rivers of the region flow from the TianShan and Pamirs. Most of the ranges of these mountains are covered with snow

FIG. 10

SOVIET CENTRAL ASIA: MAJOR RIVER-BASINS



and glaciers being the Syr-Darya, Ili, Chu and Talass. The Pamirs, though smaller in area, carry more snow and ice and this makes them the most important area in Soviet Central Asia from which the most important river Amu-Darya rises.

Among these rivers, Amu-Darya is the major source of river water with 78.46 km^3/yr of renewable water resource which is (62%) of the total river water of the region. This is followed by the Syr-Darya with 37.14km^3/yr of renewable water resource sharing around 30% of the total river water of the region. Rest of the river water in Central Asia is supplied by Chu, Talas, Assa and other small rivers. Though Irtish has 37 km^3/yr volume of internal annual renewable water resources but its outflow is more than incoming total flow, which renders this river less important in the region.

Following data shows the supply of renewable water resources by major river basins in Soviet Central Asia.

Table - 11

SUPPLY OF RIVER WATER IN SOVIET CENTRAL ASIA

RIVER BASINS	RENEWABLE WATER RESOURCE In km^3/yr
1. Amy-Darya	78.46
2. Syr-Darya	37.14
3. Chu, Talas, Assa	08.11
4. Irtish	37.00
5. Other internal rivers	28.00
Total	188.8km^3/yr.

Source :- Water Report of former Soviet union in figures(F.A.O) U.N. Rome 1997.

Overall total renewable water supplied by rivers is 188.85 km^3/yr in the whole region. But the trend of distribution of the total renewable water resources by major river basins, total incoming flow and outflow of river water is not similar in all Republics. The real trend has been shown in the data given below:-

Table - 12

DISTRIBUTION OF RIVER WATER IN REPUBLICS

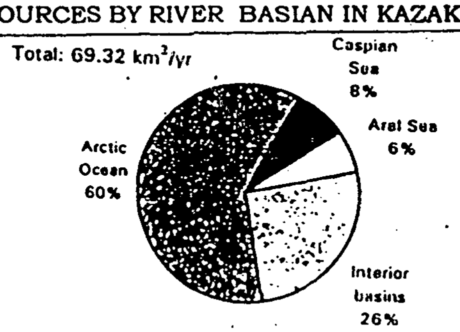
REPUBLICS	TOTAL INTERNAL RENEWABLE RIVER WATER RESOURCE	TOTAL INCOMING FLOW km^3/yr	out going flow km^3/yr
1. Kazakhstan	69.32	34.19	38.8
2. Kyrgyzstan	44.05	18.18	25.87
3. Tajikistan	63.30	13.31	63.63
4. Turkmenistan	1.00	59.50	–
5. Uzbekistan	9.54	4.84	N.A.

Source :- Water Report of former Soviet Union in figures (F.A.O.) U.N. Rome - 1997.

In Kazakhstan the total internal renewable water resource is estimated at 69.32 km^3/yr while the total incoming flow from neighbouring countries is estimated at 34.19 km^3/yr. The told outflow to the Russian Federation is estimated at 38.8 km^3/yr. In Kazakhstan four major hydrologic regions can be distinguished, depending on the final destination of water, the Arctic Ocean 60% through the ob river, Caspian Sea 8%, Aral Sea 6% through the Syr-Darya and interior basins 26%. Syr-Darya, Ob-Irtish are the major river basins in this republic.

FIG. - 11

PIE DIAGRAM SHOWING THE % DISTRIBUTION OF REVEWABLE SURFACE WATER RESOURCES BY RIVER BASIAN IN KAZAKHSTAN



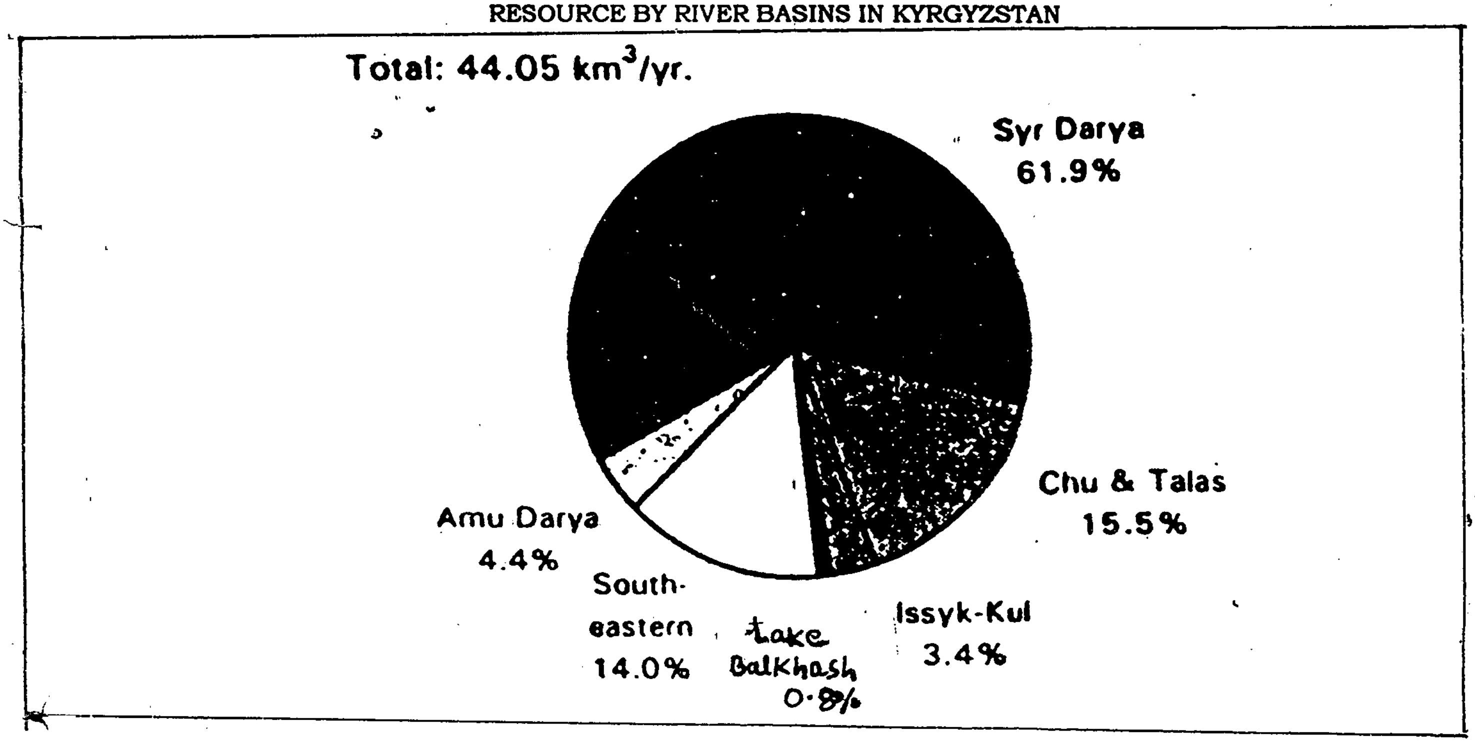
SOURCE:- WATER REPORT OF FORMER SOVIET UNION IN FIGURES (F.A.O) U.N. ROME - 1997.

In Kyrgyzstan the average annual internal renewable water resource is estimated at 44.05 km^3/yr. While the incoming flow from different river basins is 18.18 km^3/yr and total outflow is estimated at 25.87 km^3/yr. The Republic can be divided into two hydrological zones; the flow generation zone (mountains) covering 171,800 km^2 or 87% of the territory: and the flow dissipation zone of 26,700 km^2 which is 13% of the territory.

There are six main river basin groups in the Republic. The Syr-Darya is a major river basin of the Republic sharing 61.9% of the river water. Chu and Talas river basin shares 15.5%, Issyk -Kul 3.4%, Amu-Darya 4.4% and others share 14.0% of the internal renewable water resources by river basins.

FIG. -12

PIE DIAGRAM SHOWING THE % DISTRIBUTION OF RENEWABLE SURFACE WATER RESOURCE BY RIVER BASINS IN KYRGYZSTAN

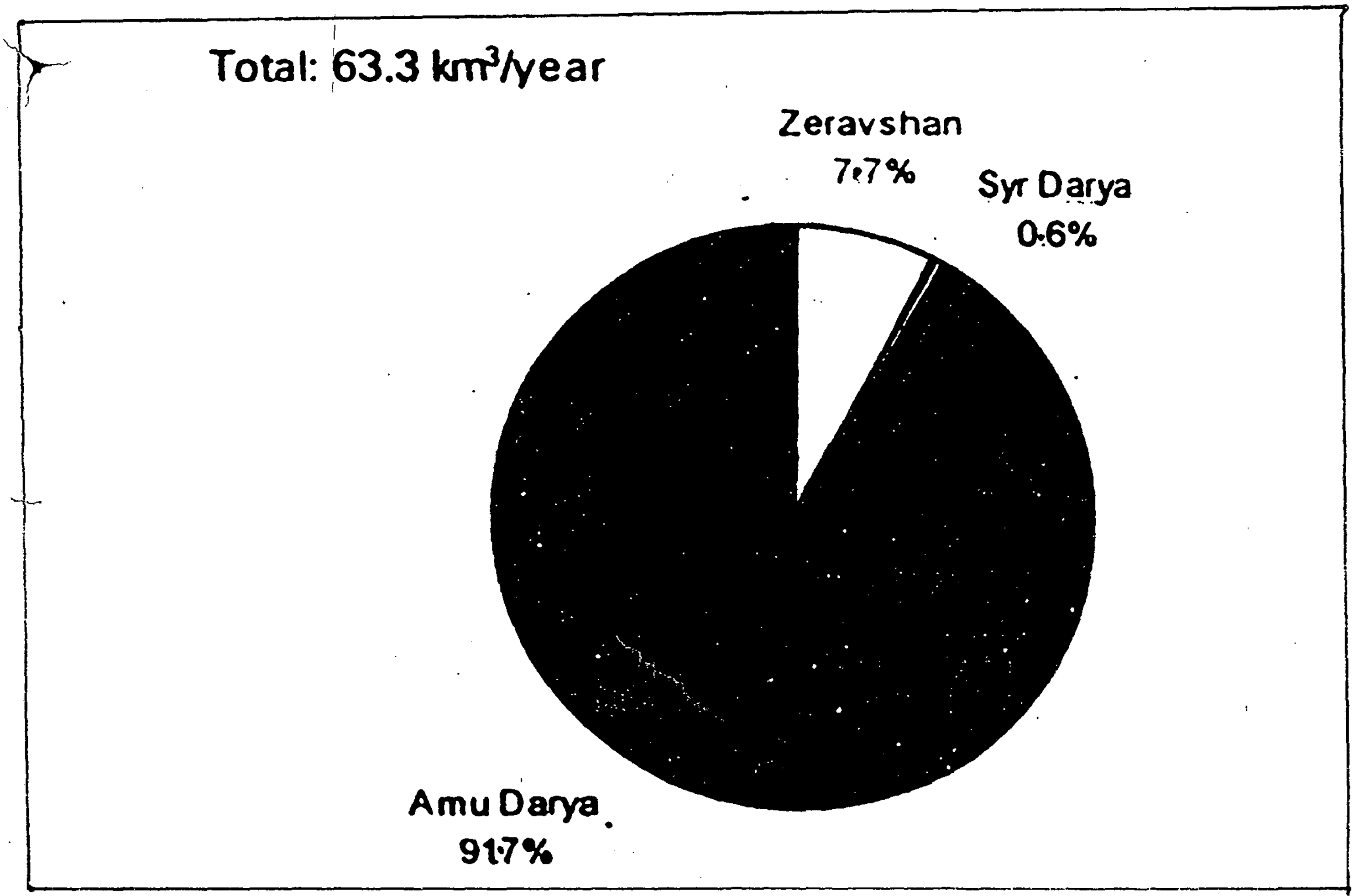


SOURCE:- WATER REPORT OF FORMER SOVIET UNION IN FIGURES (F.A.O) U.N ROME - 1997.

The total internal renewable water resources by river basins of Tajikistan are estimated at 63.3 km^3/yr. The total incoming flow of river water is 13.37 km^3/yr and outflow is 63.63km^3/yr which is highest among the five Republics in Soviet Central Asia. Amu-Darya is the major river basin of the Republic. It share 91.7% of the internal renewable water resources by the river basins, in the region. This is being followed by Zeravshan river (7.7%) and Syr-Darya (6%).

FIG. – 13

PIE DIAGRAM SHOWING THE % DISTRIBUTION OF RENEWABLE SURFACE WATER RESOURCES BY RIVER BASINS IN TAJIKISTAN

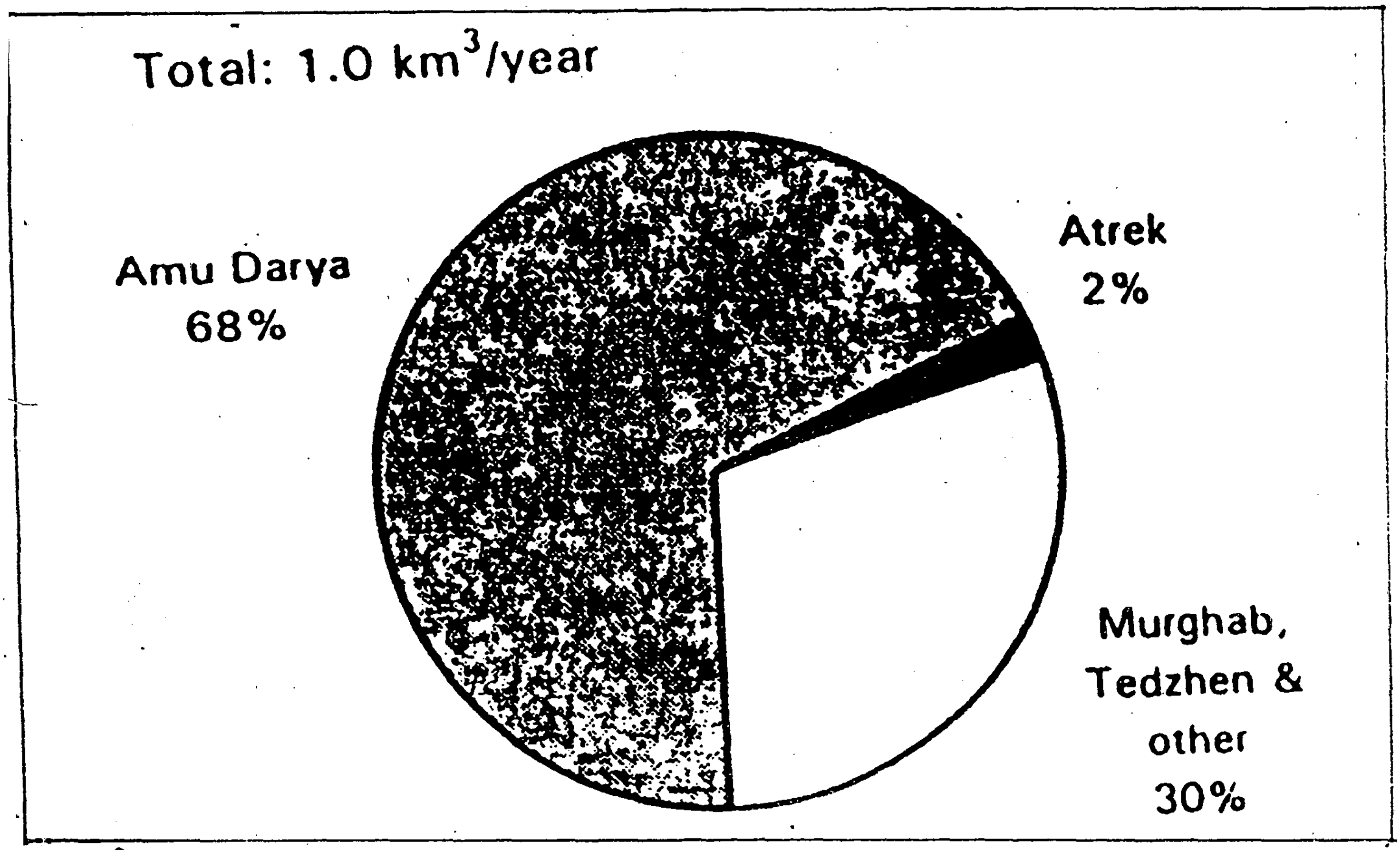


SOURCE :- WATER REPORT OF FORMER SOVIET UNION IN FIGURES (F.A.O) U.N. ROME – 1997.

In Turkmenistan the river runoff originating is estimated at 1.0 km^3/yr. Several rivers are found in Turkmenistan, most of them flowing into the country from its neighbours. It has highest incoming flow in the whole region estimated at 59.5km^3/yr. There is no outflow of river from this Republic. Amu-Darya supplies 68% out of the of river water in the Republic, followed by Murghab and others (30%). Atrek river shares 2% of renewable river water resources in the Republic.

FIG. - 14

PIE DIAGRAM SHOWING THE %DISTRIBUTION OF RENEWABLE SURFACE WATER RESOURCES BY RIVER BASINS IN TURKMENISTAN

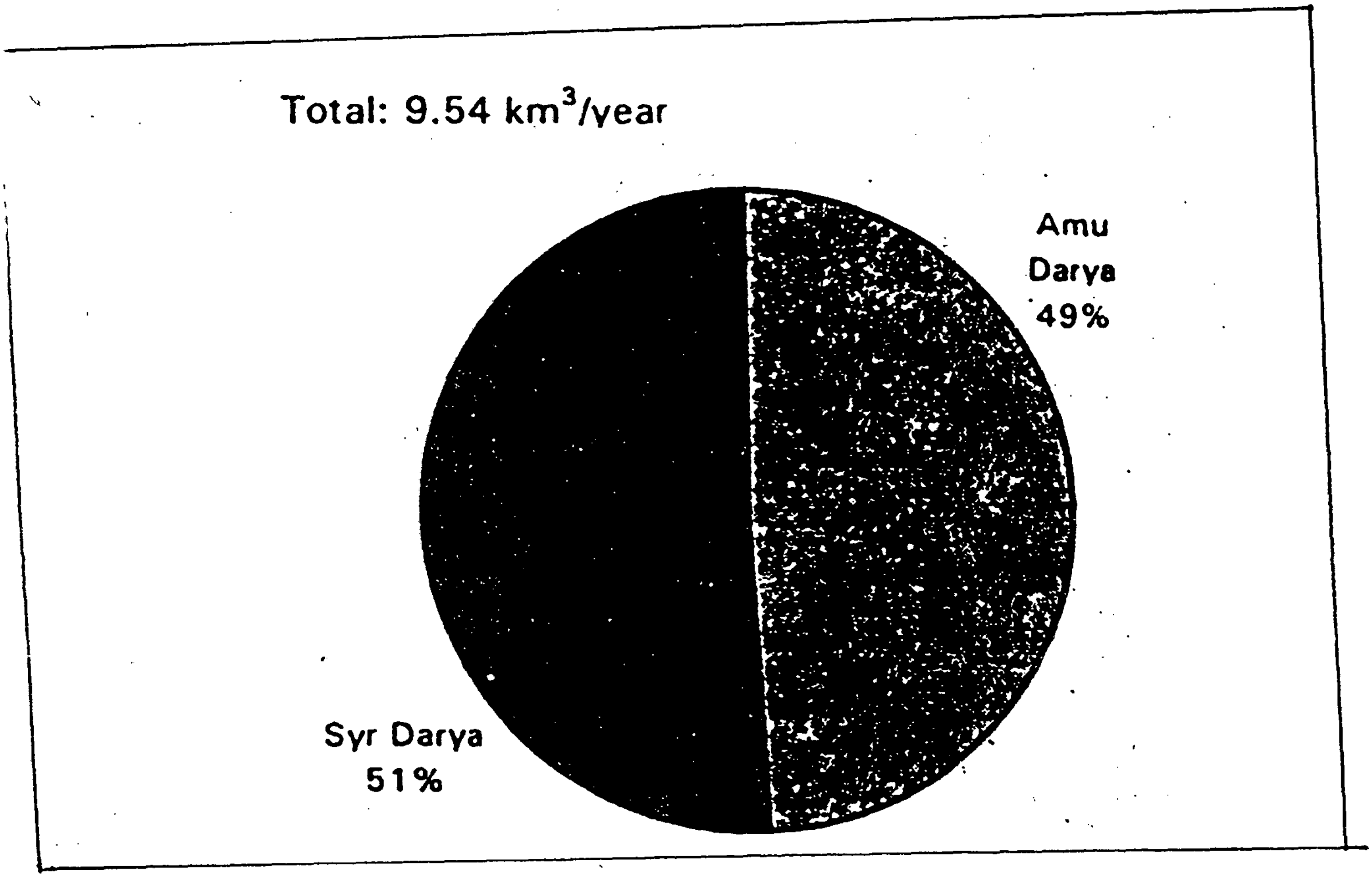


SOURCE:- WATER REPORT OF FORMER SOVIET UNION IN FIGURES (F.A.O) U.N ROME - 1997.

The total internal renewable water resources by river basins in <u>Uzbekistan</u> is estimated at 9.54 km^3/yr. Here incoming flow is very less just 4.84 km^3/yr. This shows that outflowing river water is more in this Republic but the actual data of outflow is not available. In this Republic Syr-Darya shares 51% in the total internal renewable water resources by the river, followed by Amu-Darya (49%).

FIG.-15

PIE DIAGRAM SHOWING THE % DISTRIBUTION OF RENEWABLE SURFACE WATER RESOURCES BY RIVER BASINS IN UZBEKISTAN



SOURCE :- WATER REPORT OF FORMER SOVIET UNION IN FIGURES (F.A.O) U.N. ROME – 1997.

Thus in the whole region Kazakhstan has the highest volume of internal renewable water resources by major river basins. It is followed by Tajikistan and Kyrgyzstan. Turkmenistan has the lower percentage of river water in the region the incoming flow of river water is highest in Turkmenistan 59.5km^3/yr and lowest in Uzbekistan 4.84 km^3/yr. The outflow is highest in Tajikistan 63.63km^3/yr followed by Kazakhstan 38.8km^3/yr. This is due to the situation of high snowy mountains in both republic from where major perennial rivers originate.

LAKES AND RESERVOIR:-

Alongwith rivers lakes and reservoirs are another major source of surface water in Soviet Central Asia.

Though Caspian Sea is the largest lake in the world, it doesn't shares it water at large scale in Central Asian Republics. Caspian only touches the boundary of Kazakhstan and Turkmenistan Republics. Aral Sea is the largest lake of the region located in a depression in the Turan plain being fed by two major rivers the Amu-Darya in the south and the Syr-Darya in the north. Its surface area is 66,000 km^3. Average annual internal renewable water in the Aral Sea is estimated at 115.6 km^3/yr. Balkhash lake is 8.66 km^3/yr. Apart from these two big lakes, there are number of small lakes in Central Asia, including lake Karakul of Tajikistan and lake Aydarkul of Uzbakistan. Overall the total volume of water resources stored in the lakes was 1275.5km^3 while the annual average internal renewable water in lakes was estimated at 134km^3/yr.

Following data shows the volume of annual internal renewable water resources stored in lakes.

Table - 13

LAKES AS A SOURCE OF WATER RESOURCES IN SOVIET CENTRAL ASIA

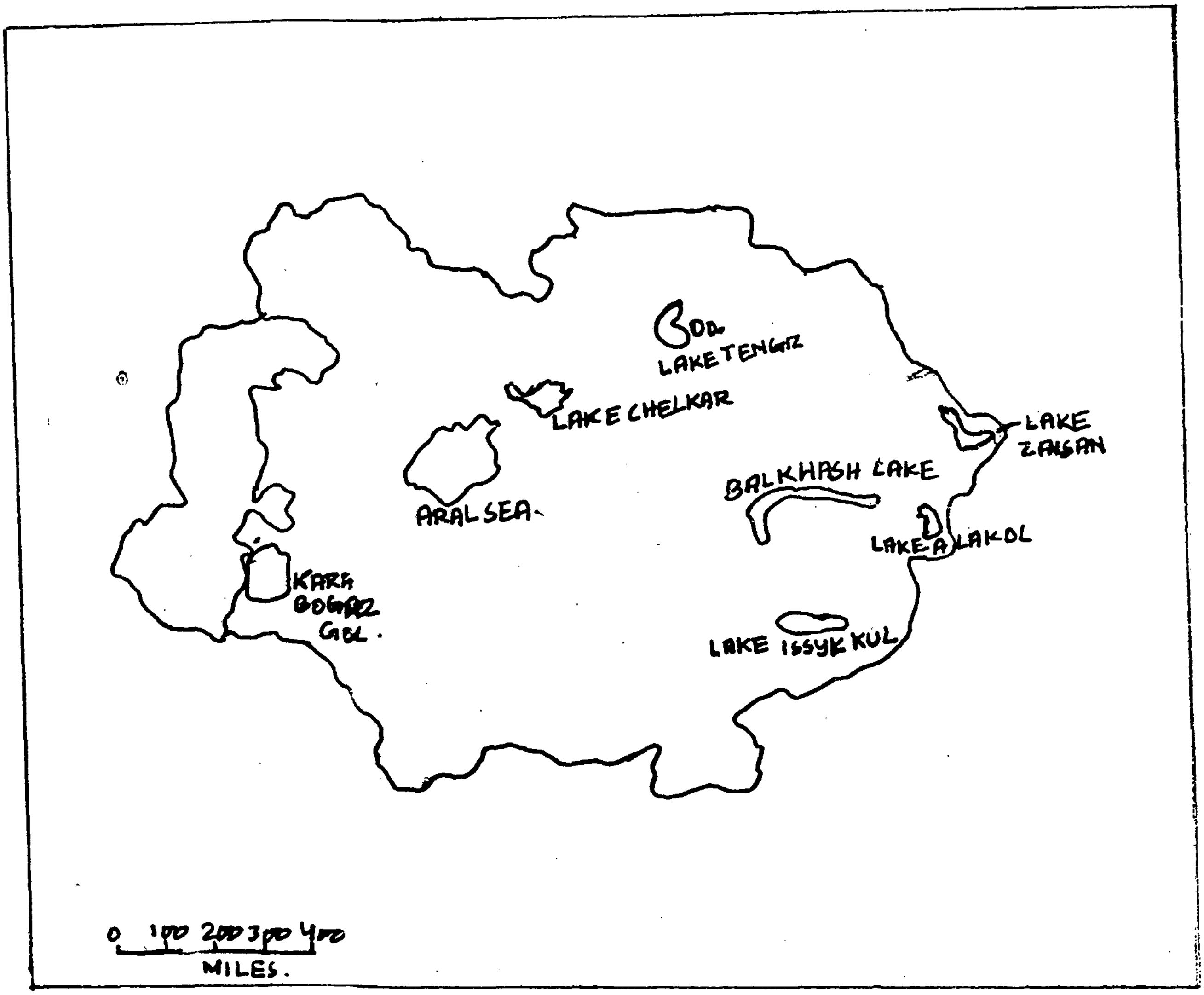
LAKES	REGIONS	VOLUME OF WATER IN km^3	ANNUAL INTERNAL RENEWABLE WATER RESOURCE IN km^3/yr
1. Aral Sea	Kazakhstan & Kyrgyzstan	1060	115.6
2. Lake Balkhash	Kazakhstan	112	8.66
3. Lake Issyk-kul	Kyrgyzatan	15	1.5
4. Lake Karakul	Tajikistan	26.5	2.65
5. Lake Aydarkul	Uzbekistan	30	3.0
6. Sarykamish	Uzbekistan	8	.8
7. Lake Tengiz	Kazakhstan	12	1.2
8. Sudochie	Uzbekistan	2	.2
9. Parsankul	Uzbekistan	2	.2
10.Lake Sarakamysh	Turkmenistan	8	.8
Total		1275.5	134

Source :- Water Report of the former Soviet union in figures (F.A.0) of United Nations. Rome - 1997.

<u>Reservoirs :</u> are the natural or artificial lakes, the water of which is used for irrigation, in producing hydroelectricity, in manufacturing process and for domestic purposes. Reservoirs are generally situated in the course of river beds. In Soviet Central Asia there are around 285 big and small reservoirs which have more than 163 km^3 volume of water resources. Kazakhstan and Turkmenistan have highest number of reservoirs with highest volume of water resources.

FIG.- 16

SOVIET CENTRAL ASIA: MAJOR LAKES



Following data shows the volume of water stored in reservoirs in all five Republics of the region.

Table - 14

RESERVOIR AS A SOURCE OF WATER RESOURCES IN SOVIET CENTRAL ASIA.

REPUBLIC	NUMBER OF RESERVIOURS	WATER VOLUME IN km^3
1. Uzbekistan	50	19
2. Turkmenistan	18	2.89
3. Tajikistan	19	29
4. Kyrgyzstan	18	23.5
5. Kazakhstan	180	88.75
Total	285	163.14

Source :- Water Report of the former Soviet union in figures (F.A.O) of United Nations. Rome - 1997.

<u>Glaciers :-</u> Glaciers are originally a river of ice moving down a valley or a mass of snow and ice formed by the consolidation of snow falling on high ground moving outward and downward from the zone of accumulation to lower ground. In Soviet Central Asia huge amount of water is contained in mountain glaciers. Pamir mountain system has the largest glacier area and glacier runoff followed by Gissar-Alay, Tienshan and Dzungrian Alatau mountain system.

In Soviet Central Asia, glaciers cover an area of 17, 940 km^2 with a water supply of 1,400 km^3.[1] The mean annual runoff from the glaciers is 19km^3/yr, or 14% of the total annual runoff and 37% of the summer runoff from the mountains. In years of enhanced ablation,

[1] Izvestiya Akadamic Nauk SSSR, Seriya Geograficheskaya 1982 No - 1(pp. 420-21).

glacier runoff may rise by 20% to 23km^3 representing 20% of annual runoff and 50% of Summer runoff"[2].

In Soviet Central Asia the water supply in glaciers is highest in Aral Sea drainage basin (870 km^3) followed by Pamir (660 km^3) and Tienshan (520 km^3). Around 320 km^3 of water supply from glaciers of Soviet Central Asia drains into the Chinese river basins.

The data of glacier runoff resources is given below:-

Table - 15

GLACIERS RUNOFF RESOURCES IN SOVIET CENTRAL ASIA

Mountain system or drainage basin	Water supply in glaciers (km^3)	Glacier runoff km^3/yr		% of total runoff	
		Total	Meltwater	Annual	Summer
Pamir	660	8.42	8.25	No data	No data
Gissar - Alay	130	3.4	3.3		
Tien-Shan	520	3.4	3.3		
Dzungarian basin	42	1.26	1.11		
Amu-Darya basin	_	9.37	9.18	15	44
Syr-Darya basin	_	2.53	2.25	6	20
Lesser basins	_	1.89	1.77	14	39
Aral Sea basin	870	13.79	13.20	14	38
Basins draining into other lakes	150	2.78	2.43	11	25
Basins draining into China	320	2.31	1.85	34	54
Total Central Asia	1400	18.88	17.46	14	37

Source :- Soviet Geography, Vol XXII No. 6 June 1982 (pp: 53-59)

Ground Water :-

Ground water is that part of water which is derived from the percolation of rainwater, from water trapped in a sediment at its time of deposition and from magnetic sources lying under the surface of the ground above an impermeable layer but excluding underground

[2] Ibid.

streams. In Soviet Central Asia due to less annual precipitation and very few perennial rivers, ground water plays major role as a dominant source of water resource in the region. Here groundwater is a most reliable source of domestic / portable water supply. Ground water is the most favourable source for satisfying the consumers with high demands for reliability of a water supply system, since the groundwater due to its persistence is characterized by negligible changes over a period of time.

The annual renewable ground water resources in whole of Soviet Central Asia were estimated at 82.39km^3/yr. This groundwater is extracted from existing pumping facilities in urban and industrial area as well as for irrigation purpose also. The groundwater as an irrigation source may be used as basic source in case of independent irrigation, supplemental source, seasonal source, periodic source or temporary springs.

Kazakhstan width 29.77km^3/yr volume of water has the highest volume of groundwater resource in Soviet Central Asia. It is followed by Uzbekistan and Tajikistan. Turkmenistan has lowest amount of groundwater in the whole region, which is due to lack of rainfall and less supply of surface water in the Republic.

Table - 16

GROUND WATER IN SOVIET CENTRAL ASIA

Region	Annual renewable ground water resources in km^3/yr
1. Kazakhstan	29.77
2. Kygyzstan	13.60
3. Tajikistan	15.98
4. Turkmenistan	3.36
5. Uzbekistan	19.68
Total	82.39

Source :- Water Report of the former Soviet Union in figures (F.A.O) of United Nations. Rome, 1997.

Thus in the whole of Soviet Central Asia precipitation provides 1350.78 km^3/yr of annual renewable water resources. But very little percentage of rain water is available for human use and surface or groundwater runoff or stable runoff. Most of the rain water goes back into the atmosphere through evapotraspiration and some part of rain water percolates in the sandy ground. Rivers are the major source of water resource in Soviet Central Asia, with more than 80% of water supply coming from rivers. Rivers provide around 188.85 km^3/yr of annual renewable water resources, while glaciers provide 18.88 km^3/yr of renewable water resources. Groundwater is the most reliable source of domestic/portable water supply providing 82.39 km^3/yr of annual renewable water resources. The total internal annual renewable water resource in the whole of Soviet Central Asia is 205.87 km^3/yr as against the total actual renewable water resources in the whole region being 221.3 km^3/yr.

The following data shows the overall assessment of sectoral water availability in the whole region.

Table - 17

OVERALL ASSESSMENT OF SECTORAL WATER AVAILIBILITY IN SOVIET CENTRAL ASIA

Sources of water	Annual renewable water resources km^3/yr
1. Precipitation	1350.78
2. Rivers	188.85
3. Lakes	134
4. Glaciers	18.89
5. Groundwater	82.39
6. Internal renewable water resource in the whole region	205.87
7. Total actual renewable water resources in the whole region	221.3

Source :- Water Report of the farmer Soviet union in figures (F.A.O) of United Nations. Rome, 1997.

Thus surface water which includes rivers, glaciers, lakes and reservoirs provides 88% of the annual renewable water resource in the region. While as ground water provides just 12% of the annual renewable water resources.

SECTORAL USE OF WATER RESOURCES

The economic theory of scare resources, originally articulated by Ricardo and Malthus in the nineteenth century, doesn't really address the complexity of water being an economic resource. Water can be considered as both a renewable and a non-renewable resource - the former on a global and often on a local scale, particularly where supply is from rainfall and rivers, but the latter in areas that rely on groundwater supply in excess of both the natural rate of replenishment and surface water such as lakes and rivers which have been permanently contaminated by pollution.

Consumption of fresh water is a function of specific water usage and of users' characteristics. For a particular use in a particular climatic region, the demand for fresh water should be a function of both the user's income and the price of water. Indeed, for all uses except for domestic, the price should be the governing determinant of water use, other things being equal. The economic use of water resources remains concentrated on agricultural and municipal water use, giving less attention to the demand for recreational, transportational, power and industrial sector.

In Soviet Central Asia water is mainly used in three major sectors: agriculture, domestic and industries. Water requirements for energy, navigation, fisheries, mining, environment and recreation have a negligible net consumption trend in the region, although they may represent a significant part of the water resources.

USE OF WATER IN AGRICULTURAL SECTOR:-

On the global level agricultural sector by far is the major user of water with an average of 69%. In Soviet Central Asia, agriculture accounts for 91% of the total annual renewable water consumption. Soviet Central Asia has around 43,448,300ha of cultivated area and irrigation is done in 26.2% of the cultivated area. Most of the irrigated land is occupied by wheat, fodder, cotton, barley, oil crops, maize, vegetables and sugarbeet etc.

Though there is high consumption of water in agricultural sector, the pattern of annual withdrawal of water resources within the Republics shows variation. Turkmenistan with 98% of annual water has the highest % of annual water withdrawal in agricultural sector, followed by Kyrgyzstan and Uzbekistan with 94% each. Kazakhstan with 81% has the lowest annual water withdrawal in agriculture.

Table - 18
ANNUAL WITHDRAWAL OF WATER IN AGRICULTURE SECTOR IN SOVIET CENTRAL ASIA

Republics	Annual water withdrawal		
	Total water of the region	Million m³	% of total
1. Kazakhstan	33674	27413	81
2. Kyrgyzstan	10086	9496	94
3. Tajikistan	11874	10961	92
4. Turkmenistan	23779	23191	98
5. Uzbekistan	58051	549366	94
Total	137464	125527	91

Source :- World Development Report, 1982. Published for the World Bank Oxford University Press.

In Soviet Central Asia more than 94% area is irrigated by surface irrigation and 6% area is irrigated by sprinkler and micro irrigation.

The source of irrigation water in Soviet Central Asia is surface water, groundwater and non-conventional water sources. In all the Central Asian Republics, the irrigation water comes mainly surface water (including rivers, lakes, glaciers, reservoirs etc) using over

93.7% respectively are the highest user of surface water for irrigation, while Tajikistan with 87% is the least user in the whole region.

Ground water is used on around 6% of the irrigated area of the region. Tajikistan uses the highest percentage of groundwater for irrgation, followed by Kazkhstan and Uzbekistan. The use of non-conventional water is limited in Soviet Central Asia, with only Tajikistan and Kazakhstan using it at a very localized level.

Table - 19

ORIGIN OF IRRIGATION WATER IN % BY VARIOUS SECTOR IN SOVIET CENTRAL ASIA

Regions	% of total irrigation		
	Surface water	Groundwater	Non-conventional sources
1. Kazakhstan	90.3%	7.7%	2%
2. Kygryzstan	99.4%	0.6%	_
3. Tajikistan	87%	9.5%	3.5
4. Turkmenistan	97.5%	2.5%	_
5. Uzbekistan	93.6%	6.4%	_
Total	93.7%	5.6%	7

Source :- Water Report of the former Soviet union in figures (F.A.O) of United Nations Rome, 1997.

As regards the surface water, the river waters of Amu-Darya, Syr-Darya and their tributaries are used to irrigate more than 60% of all the irrigated land, yielding about 90% of cotton and more than a third of the rice, maize and fodder crops produced in the region. High productivity of irrigated land has accounted for the continuous expansion of irrigation in the region and the increasing withdrawals of irrigation water from Amu-Darya and Syr-Darya basins especially in the upper and middle reaches. More than 80% of renewable water resources of Syr-Darya and Amu-Darya is used for irrigation. Out of 188 km^3 / yr of river's water, around 169km^3/yr of water is used in agriculture sector.[3] The withdrawal of river water in agriculture sector has been increasing year by year.

Table - 20

Years	% of withdrawal of river waters in agriculture sector out of the total stream of low
1970	71.5%
1971	83%
1972	88.4%
1973	71%
1974	90%
1975	91%

Source: Central Asian Irrigation Research Institute, Report 1980 (p.239).

Thus Soviet Central Asia has the highest level of water withdrawal for agriculture in comparison to the whole world and other region of former Soviet Union. Soviet Central Asia had more than 50% of the total irrigated area of the former Soviet Union.[4]

USE OF THE WATER RESOURCE IN DOMESTIC SECTOR

Domestic sector includes drinking water, municipal use or supply and usage for public services, commercial establishments and homes. The net consumption rate of water resource in domestic sector on global level is 8% of the total renewable water resource, while as Soviet Central Asia has only 3% domestic water consumption out of the total annual renewable water resource of the region. Ground water shares its large proportion in the domestic sector.

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[3] Izvestiya Akademi Nauk SSSR, *Seriya Geograficheskya, 1980,* No.5 (pp.35-36).

In most of the developing countries, the domestic consumption of water resource is just less than 4% as companied to agriculture sector with 90%.[5] Out of the total domestic water, largest percentage is consumed in urban sector and rural sector for drinking water and household consumption. Domestic sector consumes around 4227 million m^3 of water resources out of the total 137464 million m^3 water withdrawal in whole region.

The pattern of domestic water use is directly related to economic development, infrastructural development, level of the groundwater and surface water availability. This pattern can be seen in Uzbekistan where there is well developed urban agglomeration. Uzbekistan is also the leading Republic of Soviet Central Asia in economic and infrastructural development. That is why, with 4% out of the total renewable water resources Uzbekistan is a leading domestic water user. While with poor economy and much arid climate Turkmenistan with 1% of the total renewable water resources is the least domestic water user Republic.

Following data shows the pattern of annual water withdrawal in domestic sector in Central Asia

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[4] Irrigation in former Soviet Union (F.A.O.) of United Nations - 1997 (pp.16-17).
[5] World development report - 1990 (pp.100-1).

Table - 21

ANNUAL WATER WITHDRAWAL IN DOMESTIC SECTOR IN SOVIET CENTRAL ASIA

Republic	Annual water withdrawal		
	Total million m^3	Domestic	
		Million m^3	% of total
Kazakhstan	33674	583	2%
Kyrgyzstan	10086	301	3%
Tajikistan	11874	412	3%
Turkmenistan	23779	349	1%
Uzbekistan	58051	2582	4%
Total	137464	4227	3%

Source : World Development Report, 1992. Published for the World Bank, Oxford University Press.

USE OF WATER RESOURCE IN INDUSTRIAL SECTOR:-

Even though industry accounts for around 23% water used globally, industrial use is nevertheless an important component of overall use and its subsequent abuse, since a disproportionate amount of toxic contaminants are introduced into the aquatic ecosystem from industrial effluents. In Soviet Central Asia about 6% of the annual renewable water is used in industrial sector. Here 90% of the industrial water is used for cooling. The major water using industries, in order of use are cotton textile industry, food processing, pulp and papers, chemicals, petroleum and primary metals. But the industrial and municipal water become polluted. To overcome this problem, the Soviet government had made a plan to make wide use of conventional clean water after cooling, setting up closed cycles of water supply with local waste water treatment, setting up systems of water recycling in water deficient region of the region. In Soviet

Central Asia the use of renewable water resource in industrial sector is highest in Kazakhstan, while as Turkmenistan has the lowest with only 1% of renewable water being used in this sector.

Table - 22

USE OF RENEWABLE WATER RESOURCE IN INDUSTRIAL SECTOR

Republic	Annual water withdrawal		
	Total million m^3	Domestic	
		Million m^3	% of total
Kazakhstan	33674	5678	17
Kyrgyzstan	10086	289	3
Tajikistan	11874	501	4
Turkmenistan	23779	139	1
Uzbekistan	58051	1103	2
Total	137464	7710	6

Source: Water report of the former Soviet Union in figures (F.A.O.) of United Nations. Rome, 1997.

Thus the overall consumption of water resource in Soviet Central Asia is not similar as it is on global level. But the sectoral consumption trend is similar. At the global level, agriculture is by far the major user of water with the average of 69%, followed by industry with 23% and domestic use with 8%.[1] While in Soviet Central Asia the agriculture sector consumes 91% of the renewable water resources followed by industry 6% and then by domestic sector 3%. Largest proportion of river water is used in agriculture sector, while ground water shares its large proportion in domestic and industrial sector.

The trend of global and regional water consumption has been shown in the following table.

Table - 23

Sectors	% of annual renewable water	
	World Wide	Soviet Central Asia
Agriculture	69%	91%
Industry	23%	6%
Domestic	8%	3%

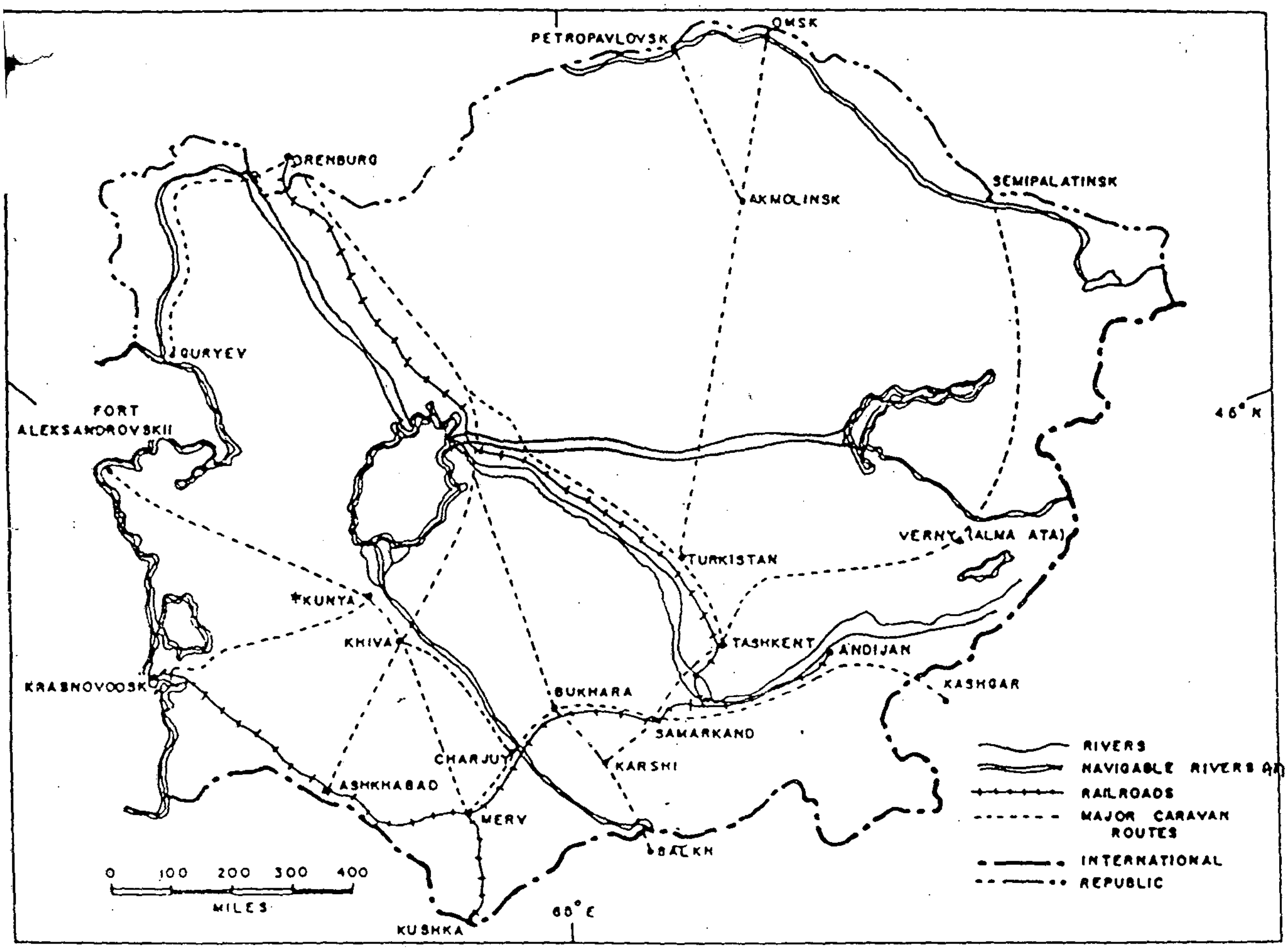
Source:- Land Water Bulletin (F.A.O.) Rome, 1997.

The use of water for in-stream needs, such as navigation, flood protection, recreation, fisheries, hydroelectricity, pollution controls is much more difficult to estimate. The transportational use of water can be estimated only on the basis of freight movement and the weight of cargo. Water transport in Central Asia has been important since early colonial period. Amu-Darya, Syr-Darya and Aral Sea and some nevigable canals are more suitable for water transport.

Thus the sectoral supply and use of water resource in Soviet Central Asia is a typical representation of environmental harshness, level of population and economic growth and their inter-relationship with viable ecosystem. Though Soviet government did try to give special attention to channel management, but it was not rational and eco-friendly. So more emphasis on the management of this valuable resource is needed.

FIG- 17

LAND AND WATER TRANSPORATION SYSTEM IN CENTRAL ASIA



CHAPTER - III

WATER RESOURCE MANAGEMENT IN SOVIET CENTRAL ASIA

There are no simple or universally applicable formula for regional or national water resource management plans to meet long term demand due to differences in climate, geology and terrain between countries as well as within countries, coupled with differences in structure traditions source of water, education, economic and political conditions.

Pressure on exploitation of water resource and its management in Soviet Central Asia had been constantly increasing owing to population growth, increasing demand for agricultural and industrial commodities, rising standards of living and growing awareness of health and sanitation. Experience of water resource management and its proper use in Soviet Central Asia has had a long history but the post-second world war period became the era of rapid social, political and economic changes in former U.S.S.R. In the meantime water resource management also became the predominant political agenda at the country level and Republic level. In particular the Central Asian region faced the major problem of water scarcity, though historically, the ability to control water resources was very important in the way their societies developed. The history of land irrigation and regional level water resource management in traditional way dated back to thousands of years in the region. But the water resource management was not highly mechanised and rationally managed. As such the water resource management in the region can be outlined in three main phases; the Pre-Russian Phas, Russian Colonialism and Soviet Period.

WATER RESOURCE MANAGEMENT IN PRE / RUSSIAN PERIOD:-

Before the Russian settlement in the region , irrigated agriculture was practiced only in the river valleys which were already moist and were mostly on a subsistence basis for local markets. Riparian vegetation was cleared and crops often actually had lower water requirements so that irrigation did not disrupt the water balance. Wheat, rice and other crops were the main staple crops as was alfafa for cattle. Fruit orchards, malons and vegetables were other important products. Silk and cotton were also produced and exported from the region. Drinking water in this period came through a system of Kariz (horizontal irrigation tunnels linking underground wells).[1]

The Khanates were territorial units ruled by dynastic families from clan associations. They were subdivided into administrative units for the purposes of taxation and administration of water for irrigation. There were two main taxes (Zekat) on merchandise, movable property, cattle and tanap (a tax on land property). Land tenure in Central Asia was closely associated with the question of

[1] Pierie R.A. 1960, Russian Central Asia - 1867-1917 ; A study in colonial rule Berkeley, CA: university of california press (pp-144-46).

water rights. Because of the region's aridity, irrigation was of prime importance, and life depended on the availability of water supply. Artificial irrigation was extensive, the canals were maintained by forced labour (the water came from Amu-Darya and Syr-Darya). Land was owned on the basis of the vicinity of well managed water resource in the region. In Khiva there were six main canals from seventy to one hundred kilometers in length. That is why half of the irrigated agricultural land was owned by the Khan and 45% of irrigated land by the waqf (religious institutions).[2]

The management of water resources and the regulation of water rights and irrigation facilities were based on ancient custom and the shariat. The distribution and sale of water, the cleaning of ditches and various servitudes were defined by custom. On the other hand the extension of aryks through the land was regulated by the shariat, which unlike customary law connected the right to water with the right to land. The right to an equitable share of the water resource was the subject of the supreme authority of the local government or the local administrative body. There was a provision for the supervision of canal maintenance and the disposition of water required election or appointment of suitable personnel. A Mirab looked after apportionment of water in each village and an aryk

[2] Izvetiya Akademi Nauk, SSSY, Seriya goograficheskaya 4. *Soviet Geography,* xx, No. 9(November), 1980 (pp. 33-35),

Aksakal had the same duty in a number of villages served by one main canal or aryk.[3]

Thus in pre-Russian period water resource management in Central Asia was in the hands of local authority. It was not exploitative, but was traditional. The sense of management was eco-friendly.

WATER RESOURCE MANAGEMENT DURING RUSSIAN COLONIAL PERIOD:-

Before the annexation by Russia, Central Asia comprised of number of Khanates and irrigated agriculture was the basic economic activity. The water supply for irrigation and domestic use had been managed on regional and smaller scale by the local administrative body. But since the incorporation of the Central Asia into the Russian empire cotton became the dominant agricultural product of the irrigated land of the region. Shortage of cotton in the world market during the American Civil War gave Russia the impetus to colonise Central Asia which provided a base for supply of raw cotton, besides other political and strategic factors. In many ways irrigated cotton was used as a tool by the Russian colonial administrators to facilitate political control of the Central Asian population.[4]

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3 Pierce R.A. 1960, Russian Central Asia 1867-1917, A study in colonial rule, Bereley, CA; university of California press (pp - 145- 147).

4 Pierce R.A. 1960 Russian Central Asia 1867-1917, A study in colonial rule Berkelely, CA; university of California press (pp. 145-147).

During this period economic incentives were provided by the Russian authorities to induce Central Asians to grow cotton in place of traditional food crops. To increase the area of cultivate able land Tsarist Russia had brought up water resource management scheme. Their main focus was on the construction of irrigation network for the reclamation of desert area. They expanded the irrigated area of the region by constructing large dams in the gorges where the major streams (such as Syr-Darya and Amu-Darya) leave the mountains and enter the plains. The water resource management by Tsarist administration was also focusing at the establishment of hydroelectric power generation on dams and reservoirs for the generating electricity.

Central Asia is insignificant for river navigation because of shallow water and the shifting nature of channels in the sands. So the administration also paid attention to the stream management of Syr-Darya and Amu-Darya. Small canal irrigation was developed in this period. Due to the availability of limited technology and less pressure of population on the land, water resource of this region was still under exploitated. Except one or two large river valley projects, there was no long-term water resource management planning.

WATER RESOURCE MANAGEMENT IN SOVIET PERIOD:-

After the success of Russian revolution in 1917 and establishment of new communist government in Soviet Russia, special emphasis on infrastructural development, irrigation and agricultural development, industrial urbanisation was given by the Soviets. Now the use of laky and rudimentary water delivery systems in the field were harnessed for uneven and excessive irrigation. Water was mainly used in irrigation of cotton, monoculture upon which the economics of this region was depended. Now the high rate of economic development, growth of population and improvement of living conditions caused a marked increase in water use, delivery of water over long distances, and distribution. This brought in the need for water resource management and conservation. Now the water resource planning was based on long term demand and it encompassed a wider range of subjects than planning of specific projects. Now the management planning had included water related issues, interaction between the water sector and other sectors of the economy or the social structure, as well as interaction and trade-offs between different water related sectors.[5]

The initial action of communist government for water-resource management planning was based on data collection and interpretation of the region on the basis of geology, hydrology, soil surveys, topography, population, water consumption, irrigation practices and water requirements, water quality, prices and costs, development plan of other sectors, human resources, cultural and

[5] Natural resources / water series No. - 21 united Nations, New York - 1988 (pp. 29-30).

traditional patterns, organizational structures, laws and regulations. The major goal of the Soviet government for regional and national water management was based on the economic interdependence of the region, land settlement, public health and income distribution, irrigation and agricultural development, urban industrialisation and mitigation of water deficit disparity. Overall the dealing of water resource management was based on agricultural, domestic, industrial, power generation, river navigation and environmental sectors. Water resource management in Soviet Central Asia can be categorised into two phase the pre-second world war period and post-second world-war period, keeping in views the intensity of government action and planning.

Water Resource Management in Pre-Second World-war Period:

In former Soviet Central Asia, before the second world-war the competition between sectors and regions was on limited scale for water resource utilization. So the water resource management plans were not very progressive in nature. Management was concentrated on the basis of assumption be that how demand can be met by supply. But the planners and the government were not thinking about how the system will operate under certain realistic assumption, including affordability of users, availability of recurrent finance for operation and management of water resource, capability of the institutional framework to cope with newly expanded water projects, availability of the necessary operation and management staff and preparedness of farmers to intensify irrigation practices.

In pre-second world-war period, the water resource management in former Soviet Central Asia was based on "hardware bias", that is water was supplied to selected areas in large quantities to lands or to users who had not been adequately prepared to absorb so much water or to operate and maintain the facilities properly.[6]

In this period the first major water construction project called the "Great Fergana Canal was completed in 1939 in Fergana valley. Until that time the Fergana Basin was rather poorly utilized with water being tapped only from minor streams to irrigate local areas, primarily along the southern side of the basin. A myriad of small streams flowing down the northern slopes of the Alay range into the southern portion of the Fergana Basin have built a string of alluvial fans sloping northward into the Basin thus affording ideal conditions for gravity-flow irrigation. Many of these small streams have been utilized for centuries because they were easy to control. But the large Syr-Darya which flows through the full length of the Basin was not pully utilised used.[7]

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[6] Natural resources / water series No. - 21 united Nations, New York - 1988 (pp.40-41).
[7] Paul E. Lydolph, Geography of U.S.S.R-1969 (pp. 247-248).

For hydroelectricity and urban and industrial water supply, Soviet Government decided to build a huge dam on Syr-Darya. In 1943 construction began on the large Ferghana Dam opposite the city of Bekabad at the western mouth of the Ferghana Basin where the noisy Syr-Darya rushes through a gorge in the Mogol Tau, on its way to the Hungry Steppe to the west. The Farkhad Dam provided hydroelectricity to the many industries that were being located in Central Asia, particularly to a variety of chemical and synthetic industries established there. It also provided water for irrigation to expand the Parhta Aral or cotton island in the Hungry Steppe.[8]

Thus in pre-second world war period, water resource management plan was localised in nature. It was not widespread in the whole region, but was concentrated only near the river beds area. The management was not capturing the demand of water in all economic sectors. Only Great Fearghana canal and Farkhad Dam were the major managerial source of water. Due to the lack of advanced water engineering ground water was also under utilized, excepting in urban centres.

Post-Second World War Period:-

After the end of second world war, to cope with the problem of reality unbalanced water availability in the region, the water resource

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[8] Baransky, N.N. Economic Geography of the U.S.S.R. Foreign language publishing house, MOSCOW, 1956, (pp. 395-402).

management plan was adjusted by the Soviet Government based on the realistic projections of the number of operators, mechanics, supervisors, artisans, accountants, economists, chemists, scientists and managers, who were available at all stages of planning, design, implementation, operation and maintenance of systems and facilities in all water-related projects.

Now the five-year and long term plans were developed on the basis of schemes for multi-purpose development and conservation of water resources. These schemes assess, the available surface and ground water resources, outlined future water needs in all economic sectors, planned for water-resource development and determined preventive measures against pollution, obstruction and depletion of water bodies. The management schemes usually included long-term water budget as well.

In 1950s, Nikita Krushchev pushed his "Virgin lands" scheme in the Central Asian region to grow wheat on the massive arid and semi-arid landmass of Kazakhstan. At the same time, cultivation of cotton assumed new importance. Cotton was sown in about two-thirds of arable land of the region. So this increase of arable land and area of cotton cultivation during 1950s and 1960s caused the spurt in irrigation system in the region. To mitigate the water problem and to distribute the limited water resource in rational way in all the Soviet Central Asia Republics, the Soviet Government implemented several water management plans such as inter-basin and inter-republican network plans, legislation, managerial structure and function plan, automated management of water resource use and conservation policy, integrated ground and surface water management plan, industrial water management plan, master plans of multipurpose use and management of water resources, and Aral Sea water management plan in the region.

These water management plans are discussed below:-

INTER-BASIN AND INTER-REPUBLICAN IRRIGATION NETWORK PLAN (1950s-1960s) :-

During the first two five year plans the Soviet government initiated a large project to tap the waters of Syr-Darya, Amu-Darya and other important rivers to irrigate much more of the arable land of the region.

The central government had also launched operations for setting up hydraulic networks for large scale inter-basin flow transfer. The major inter-republican schemes that were undertaken are discussed below:

The Great Ferghana Canal:-

This canal was completed in 1939 but it was poorly used, water being tapped only from minor streams to irrigate local areas. But after 1950s this project was expanded to tap the waters of Syr-Darya. In 1957 the sector of great Ferghana canal between Kuygan-yar and the Yaz yavan break was widened, with the result that 100 cubic metres of water per second instead of the former 70c.m. began to flow through it. In 1958 widening started between Yaz yavan for another distance of 43km. by 25 February 1959 work was finished.[9] The main canal system was about 200 miles long, completely encircling the Ferghana Basin. This project provided water to Uzbekistan and Kyrgyzstan frontier region, irrigating more than 8,00,000 hectares of arable land.

The Karakum Canal:-

The Karakum Canal, which transports water from the Aral Sea to the Caspian Sea, is the largest artificial waterway in the world and the largest scheme for inter-basin flow transfer in the former Soviet Union.[10] The canal was completed upto Ashkhabad in 1962. The canal diverts $465m^3$/sec of the Amu-Darya water across 1,000 kms of one of the hottest deserts in the world. The water way is unique not only for its extent, but also because the water runs hundreds of kilometers through the desert by gravity. The socio-economic significance of the Karakum Canal is considerable. The dream of the "great water" cherished for centuries by Turkomen people came true by this project. Irrigated area in the canal zone is about 1 million hectares. Besides, water was also supplied to 7.5 million hectares of

[9] Water resources in Central Asia-inter republican irrigation networks Central Asian review part-1 Volume VIII-1960 (pp. 142-145).
[10] Proceedings of the seventh session of the committee on Natural resources "water resources series" No. 54 united nations New York-1981 (pp 141-43).

pastures. The canal also serves as a transport line, a basis for fishery development and recreation zone.[11]

The Great Ozernyy Drainage Canal:-

This canal system supplies water to marshy and cotton land of Uzbekistan and Turkmenistan. The 212kms pilot channel of the first stage of the Ozerny drainage canal was opened in April 1961. In 1963, 180kms Dar-yalyk drainage canal was joined to the Ozernyy.[12] The total capacity of the canal is 95 cubic meters of water per second.

Kashka Dariya Valley Project:-

An even bigger project which had been approved in 1960 to irrigate the Karshi steppe was Kashka Darya Valley Project. The Soviet plan for this project envisaged the erection of a barage on the Amu-Darya at Kizyo-Ayak to increase the amount of water entering the Karakum canal so that it could be extended to the Caspian. The first section of the Krashi canal was irrigating 200,000 hectares of land. The area was producing about two million tons of cotton, which is more than the produce of whole Ferghana valley, as well as many other crops.[13]

Meanwhile irrigation in the Kashka-Darya Valley was improved by the completion of Chimkurgan reservoir which is storing almost 500 cubic meters of water when full, and the reconstruction of the

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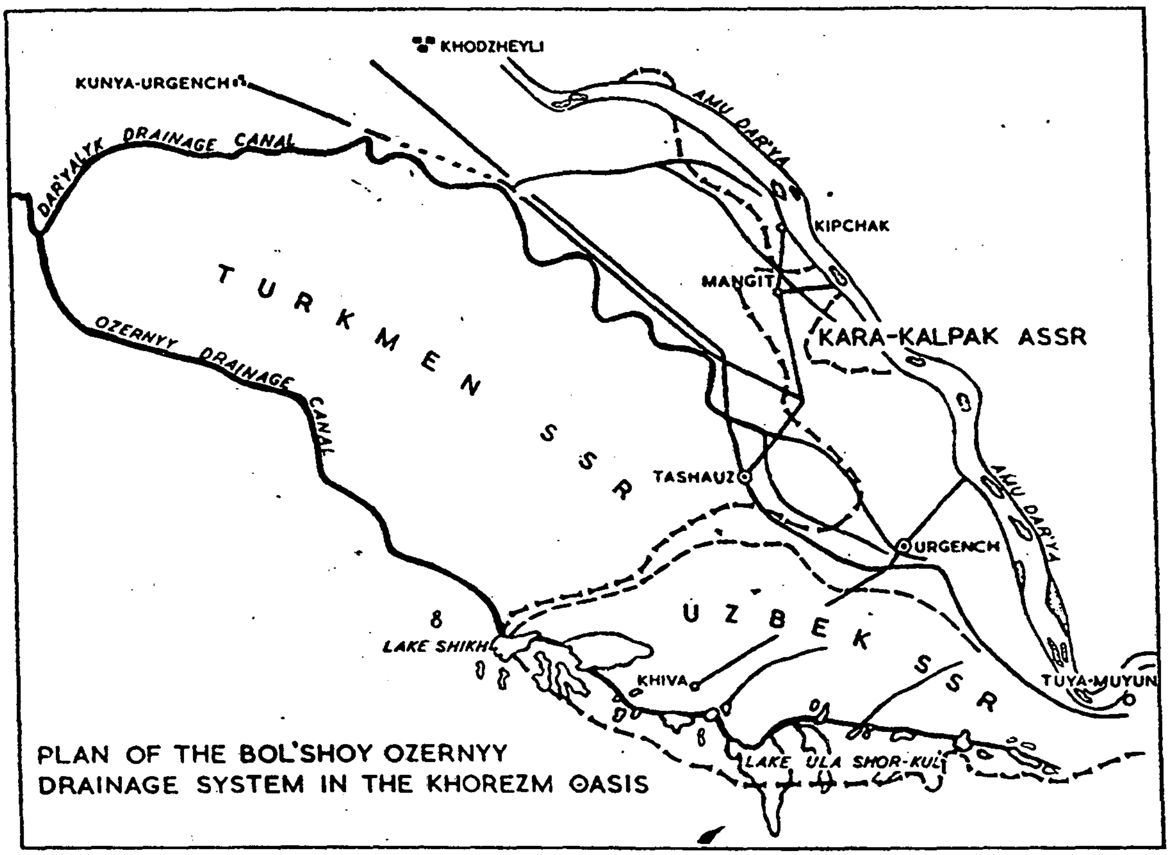
[11] Paul E. Lydoph, Geography of U.S.S.R, New York 1964 (pp. 250-251).
[12] Central Asian servey, Vol-IX 1982 (pp. 138-144).
[13] Central Asian survey vol-IX 1982.

FIG – 18

MAP OF THE GREAT OZERNYY DRAINAGE CANAL



URCE:- CENTRAL ASIAN SURVEY VOL IX 1982 (P-140).

irrigation systems of the lower and middle Kashka-Darya. Pachkamar reservoir on the Gujar-Darya which was finished in 1965, is irrigating 20,000 ha of the Karshi Steppe.[14]

South Surkhan Project:-

Immediately adjacent to the Kashka-Darya Basin is the Surkhan-Darya Basin. An earth dam 32 meters high was built across the Surkhan-Darya during the period 1960-1962, in order to provide irrigation water for 180,000 hectores in the lower part of the valley just upstream from where the river enters at Termez. This was one of the warmest spots in the former Soviet Union. It afforded the possibility of high cotton yields and second cropping after the cotton harvest. Thus the project had been deemed worthwhile inspite of the necessity of flushing the generally saline soils.

The Vakhsh Basin:-

Continuing eastward across the Tadjik boundary lies the Vaksh river and other headwater streams of the Amu-Darya which flow from north to south across the long staple cotton lands of the Yavan-obi-kiik Maggif in south western Tajikistan. Several water construction projects exist in this region but by far the largest project is the high Nurek Dam on the Vakhsh just south east of the capital city of Dushanbe. This project has been completed in 1970s. The dam is 1 kilometer long and 300 metres high. The ultimate capacity of this

[14] Deuxlney, John C., A Geography of the Soviet union pergamon, Oxford 1965, (pp-134).

hydroelectric plant is 2,700,000 kilowatts, which makes it by far the largest in Soviet Central Asia.[15] Part of electricity was used Regar aluminum plan. This reservoir also provides water for irrigation.

Tashkent Oblast:-

This irrigation system has two reservoir Tyuya-Buguz reservoir (Rashkent Sea) on the river Angren and another one is Charvak reservoir on Chirchik river. The Tyuya -Bugug reservoir supplies 250 cubic metres of water for irrigation along the Tashkent canal of 62,000 ha. of land as well as allowing more than 30,000 ha. to be claimed on the left bank of the Chirchik and in the lower reaches of the Angren. Charvak reservoir stores more than 1.5 milliard cubic metres of water.

This provides enough water for the irrigation of 240,000 ha of virgin land in the valleys of the Chirchik, Angren and Keles, including 158,000 ha. in Tashkent Oblast alone where the land is already in good condition and settled and in dry years it ensures a supply of water to 335, 000 ha. land. In addition, the Charvak complex eliminates the dangers of flooding in the Chirchik valley. This complex has the biggest hydroelectric power station in Uzbekistan generating two milliard kwh. of cheap electricity per year. It also provides a site for a new health and holiday resort on the reservoir at Khodzhikent with easy access from Tashkent and Chirchik.

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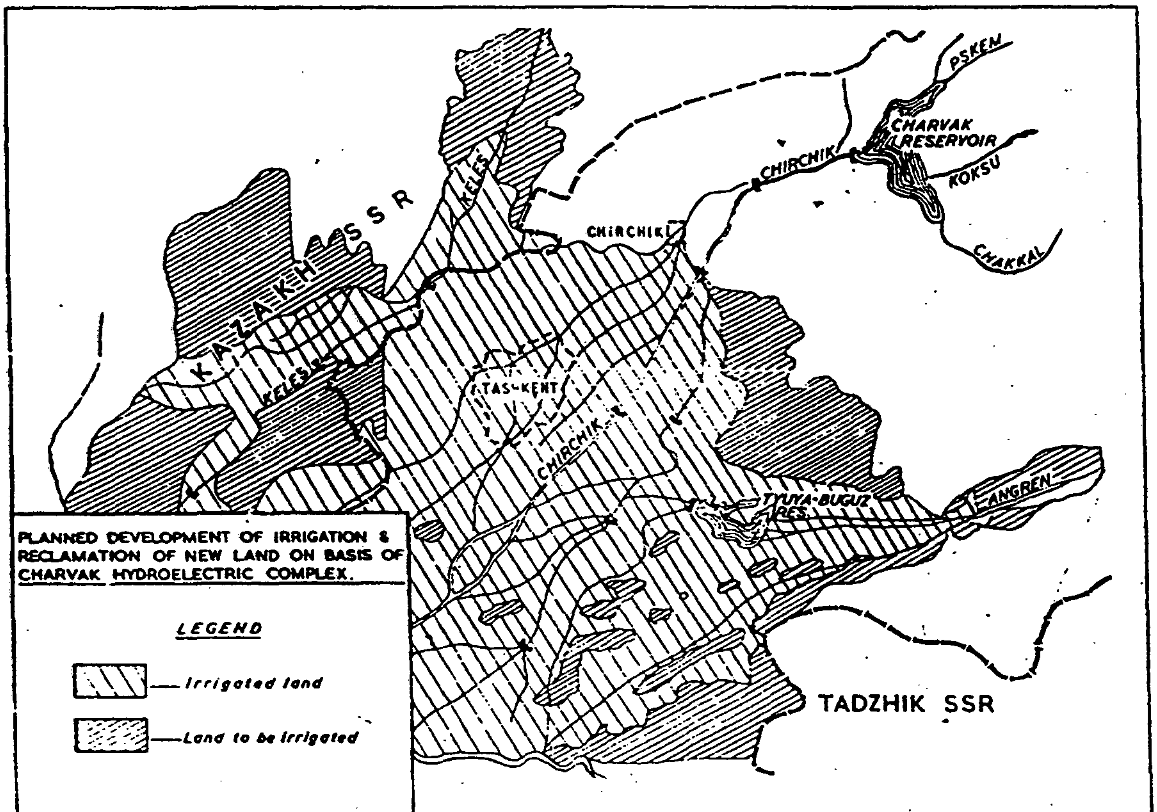
[15] Paul E. Lydolph, Geography of the U.S.S.R, New York - 1964 (pp. 254-255).

FIG. - 19

MAP OF TASHKENT OBLAST



SOURCE :- CENTRAL ASIAN REVIEW PART - I VOL - VIII 1960 (P-141)

Zeravshan Valley Project :-

This water project has two canal systems Miankal - Khatyrcha canal, was completed in 1959-62. This canal system provides water for irrigation to 60,000 ha. of arable land in the Ishtykham. Khatturgan and Khatyrcha rayons. Since this canal was not able to supply enough water, in 1963 the Soviet government decided to make another Amu-Bukhara canal. This canal is based on gravity flow system. In this canal system, water from Amu-Darya has been pumped along it to Bukhara oasis where 66,000 ha. land started receiving more reliable irrigation. Besides, 24,000 ha of waste land was reclaimed . In addition irrigated land in Samarkand Oblast has no longer experienced water shortages. The canal is almost 160 km long.

Besides these important canal systems, Soviet Government constructed a number of other inter-republican irrigation networks like.

a) The Great Chu canal system, on Chu river which provides water to Kirgizia and Kazakhstan.

b) Kyzyl Kum canal system on Syr-Darya providing water to Kazakhstan and Uzbekistan.

c) Khorezm canal system between Uzbekistan and Turkmenistan .

Thus in 1950s and 1960s the government policy focused mainly on the supply of water through canal irrigation system. But still there was lack of management compactness in the planning.

LEGISLATION ON MANAGERIAL STRUCTURE AND FUCNTIONAL PLANS (1971)

The long-term water resource management plan encompassed a wider range of subjects than planning of specific projects. So to bring up compactness in the planning, Soviet government launched a Legislation Managerial structure and functional plan for water resource management in the region.

(a) Legislation

The need for the extension of state administration in the field of water resources usage and conservation led to the enactment in 1971 of a new water law, called Basic Principles of Water Legislation, for the former U.S.S.R as a whole and for individual Republics.[16] This legislative document contained general provisions and basic principles for utilization and protection of rivers, lakes, seas, reservoirs and other surface and ground water bodies in the territory of the Soviet Union, which were compulsory for implementation by all ministries, departments, governmental bodies, enterprises, institutions, organisation and citizens.

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[16] Proceedings of the fourth session of the Committee on Natural Rasources. Held at Benkik. Thailand 16-2 August 1977, water resource series No-48 (U.N) New York - 1977. (pp. 85-99).

The basic principles provided for the establishment of a unified state system of record keeping and planning of water resources use, based on state water cadastral data, water budgets and schemes for the integrated use and conservation of water resources. In order to prevent water resource depletion and to ensure optimum national utilization, the basic principles stipulated that the operation of existing industrial enterprises and the construction of new ones which require fresh water, was allowed only with the approval of the authorities concerned with the regulation of the utilization and conservation of water, which in turn should act in accordance with the provisions of schemes for the integrated use and conservation of water resources and water budgets. It was prohibited to put into operation new and reconstructed enterprises, shops, units, communal and other complexes that were not provided with facilities for the prevention of water pollution.

Industrial water users were obliged to take measures to reduce water consumption and stop waste water discharge by improving production technology and water supply schemes (i.e. application of waterless technological processes, air cooling, recirculating water systems). Waste water discharge was allowed only in cases when it didn't lead to an increase of the pollutant content in the water body over an established level. In addition, enterprises, organizations and institutions were prohibited from polluting or obstructing surfaces with industrial, domestic or other waters, sewage and effluents. With a view to conserving water for potable and domestic water supply and for therapeutic resort and health improvement needs for the population, special zones of sanitary protection had been established in the Soviet Central Asian region.

(b) **Managerial structure and function** :-

It was divided into two parts (i) administration and (ii) co-ordination.

(I) **Administration** :-

In Soviet Central Asia, administration of water management was carried out directly by the Council of Ministers of the Union and Republics, the executive committees of local Soviets People's Deputies, and authorized state agencies for the regulation of water use and conservation through basin administration. The central ministry of land reclamation and water management and local authorities of all five Republics of Soviet Central Asia were entrusted with solving the major problems concerning the rational use and conservation of water resource in the region. The USSR Head Administration of the hydro-meteorological service together with the Ministry of Geology were responsible for the assessment of surface and ground water resources and compilation of the sate water cadastral data.

The USSR ministry of land reclamation and water management for the Union and the corresponding ministries in the five Soviet

Central Asian Republics with subordinated organization from a unified system of sectoral, regional and specialized bodies undertook planning, budgeting, research, design, construction and operation of water projects. Special attention was also given to integrated water resources use and pollution and depletion controlling work. The supervision of design was the responsibility of the All-Union Design Association at the Ministry of Land Reclamation and Water Management. Similar structures with slight variations were found in the ministries of land reclamation and water management in all the Republics of Soviet Central Asia.

(II) **Co-ordination**:-

Apart from the carrying out of the development plans in land reclamation and water resources, the ministry of land reclamation and water resource management in the centre and Soviet Central Asian Republics co-ordinated, within their terms of reference for, water development efforts in other sectors, such as power engineering, water transport and industry. Water cadastral data and the estimates of current and future water needs were used to determine current and prospective water budgets for the whole region which specified volume of water intake and waste water discharge for all major rivers and water basins.

After 1960s, the co-ordination of the activities of various departments in the field of water resource usage and conservation became most essential.

Water bodies had long been used for the discharge of industrial and domestic waste water. Formerly, in view of the low level of production such practices didn't cause detrimental effects and didn't require general management. However, intensive economic development, population growth and the rising standard of living contributed to increased discharges of industrial and domestic waste into water basin. Cotton monoculture and use of fertilizers and pesticides in the farms on large scale were responsible for water pollution which reached a dangerous level for people's health.

Government policy of water resource management did help reducing the soaring level of pollution of the major river basins in the region.

AUTOMATED MANAGEMENT OF WATER RESOURCES USE AND CONSERVATION POLICY (1970s):-

The management of water resources use and conservation, including the quantitative and qualitative aspects of regulating water intake and discharge was very complicated as a result of the diversity of incoming information and multi-faceted nature of water use in the region. So in order to ensure effective management of water resource, it was necessary to introduce mathematical interpretation and computerization of water resources data. The automated management was already practised widely in the USSR for the solution of administrative problems in land reclamation and water development by Republic's ministries and large water development organizations. Such problems included programming of general planning, financial accounting and provision of construction material and equipment. So this automated scheme was projected in water management. The automated managerial group gave major consideration to following factors:-

(i) Dependence of hydrological information on probability,

(ii) Uneven distribution of water flow in space and time,

(iii) Scattered location of information sources,

(iv) Multi-purpose nature of water use,

(v) Competing requirement of users in the area of a water basin,

(vi) Close relationship between water resources activities and the environment and the impact of ecological factors on the use of water resources.

Schemes of automated management of water systems were prepared in Syr-Darya, Amu-Darya river basins, as well as other irrigation systems. The application of computers for the management of these river basins and the optimization of water distribution and the imposition of strict controls over water use resulted in improved agricultural production, enlarged power generation capacity, reduced losses in fisheries and better conditions for water transport. The tasks of management were to forecast water resources availability and water use for various periods to plan water distribution on an integrated basis and to control effectively water supply regimes. To fulfill the above tasks it was necessary to have information on water availability in reservoirs, forcasts on river flow and an assessment of the conditions of the whole water system and hydraulic structures.[17]

The central computer processed the information related to long-term forecasting and planning of water distribution. Small-scale computers performed the tasks of effective planning and management as well as those of control, accounting and analysis. Telemechanic systems connected to the small scale computers rapidly supplied information on water projects and hydraulic structures.

The connection of central computer with technical equipment of a lower grade was activated through terminal facilities. By processing the results of the incoming information, the computer produced alternative decisions to the managing unit.

INTEGRATED GROUND AND SURFACE WATER MANAGEMENT POLICY:-

Soviet Central Asia has 314.7 KM^3/yr of renewable annual surface water resource and annual renewable groundwater resource is just 82.39 KM^3/yr. Due to lack of annual rainfall distribution there was more stress on surface water and limited ground water. Rapid population growth, increasing industrial development and

[17] Natural resources/water series No.-21 United Nations, New York, 1988 (pp.23-29).

urbanisation and also in the expanding agricultural land, the intake of groundwater increased through pumping. This intake rate of groundwater was greater than the average annual replenishment rate of the groundwater. To maintain groundwater intake and replenishment in the region central government of U.S.S.R. launched an integrated ground and surface water management policy in Soviet Central Asia in 1970s.

A group of water engineers was appointed to -

a) Analyse the feasibility of ground water use and subsequent replenishment period during years,

b) Using the source for identifying long time utilization of water,

c) Integration of the economic use of surface and ground water resources,

d) Evaluate the influence of groundwater use on the river yields under different climatic conditions.

The technical group gave systematic presentation of analytic methods for evaluating the river yields, reduction during groundwater intake operations, as well as the methods of electroanalouge, numeric and realtime simulation and practical case studies. These analytic methods were mainly employed for evaluating the influence of large centralized water intakes on the yield under different hydrological conditions.

The control aspect of the integrated surface and groundwater management made it possible to determine parameters and operating modes of the intakes of river and groundwater as well as to increase reliability of the management system.

The Soviet government asked the water engineers to develop a set of simulation models and programme packages for calculating integrated surface and ground water in order to solve the tasks set under the following diversity of conditions:[18]

(a) by a required water intake mode from the sources constant, conditionally constant (by calculated water supply needs), alternating (stochastic);

(b) by the degree of mastering river runoff natural (domestic), seasonal and over year regulation.

(c) by ways of hydrological information input recorded discharge hydrograph, calendar rows of hydrometric observations, hydrological rows obtained by statistical test methods,

(d) by nature of hydraulic links between ground water use and the river; i.e. complete, incomplete, no links.

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[18] Water resources development in Asia and pacific some issues and concerns, "water resources series No-62, New York, 1987 (125-128).

As a result of the calculations using the simulation models the volumes and modes of excessive and insufficient water resources in the system were obtained and the requirements for groundwater intake and its artificial regeneration assessed.

The algorithum calculation was applied for primary use of surface water, whose current resources in the water intake line were determined in accounting for all interventions into the water regime up the river flow as well as the needs for reserving in this line or transfering down the flow.

In case of diminishing due to seasonal and year by year fluctuations of river runoff resources below the established level, ground water storage came under forced use. Due to this, the river water was fully used. As a result of this system operation simulation of water economy rows, complete characteristics of volumes, dephs and water deficit frequencies were obtained.

The major water problem was solved with the policy of integrated surface and groundwater management in the region.

INDUSTRIAL WATER MANAGEMENT AND WATER RECYCLING POLICY: (1975-80):-

Constant growth in water use and waste water disposal by industrial enterprises brought about the need for a new approach to the problem of water supply in cities and industrial centres. Thus in

1975 Soviet government planned to develop and promote technological processes which would reduce the amount of pollutants and ensure maximum wastes recovery and create a system of water use on a closed cycle. In the Soviet Central Asia, annual five-year and long term plans for the conservation and rational use of water resource in industry had been drawn up within the framework of general state plans for social and economic development of the region. The principal plan indices were -

- Water use
- Water recycling
- Water re-use
- Waste-water treatment
- Capital investment in construction of treatment plants and rational utilization of water.

The targets of conservation and rational use of water resources evolved specifically for economic branches, ministries, councils of ministers of Central Asian Republics and for water management regions. The lower level for management planning in industry was classified as an enterprise, the higher being represented by a ministry.

The former U.S.S.R. Ministry of Land Reclamation and Water Management worked out master plans for conservation and rational use of water resources on the basis of plans made by industrial ministries. While planning the level of water use and waste water disposal in industry, it analysed the trends in the main indices and factors causing changes and outlined effective measures which helped in reduction in water use and in the disposal of raw waste water. Master plans for the conservation and rational use of water resources submitted by the state planning committee of Soviet Central Asia were approved by the central Soviet government.

Water recycling plan - 1975 :- The water recycling factor was one of the most essential indicators of the technical level of water use in industrial branches. This factor was determined as the ratio of the volume of water recycled and reused to the gross water used in production. This indicator measures the efficiency of water supply systems from the viewpoint of water conservation.

The water recycling system was largely a result of two factors. The first was the insufficient and scarce water resources and those fairly rich in water but with a dense urban population and a high industrial potential. The second factor was that in a number of technological processes, economic savings resulted from the recovery of valuable raw materials, reagents and power resources from waste water returned to production. The widest application was found by water recycling system in such water-consuming industries as chemicals, ferrous metallurgy, coal mining, pulp and paper and in heat-power and general engineering. In 1975 the water recycling factor in these branches reached 74 on average.[19]

To make more efficient of water recycling system the Planning Commission of former U.S.S.R. considered the following measures[20]:-

(a) stimulating rational water use at enterprise level,

(b) working out scientifically determined quality requirements for water,

(c) making wide use of conventionally clean water after cooling,

(d) utilizing municipal and industrial waste water in industrial water supply systems after necessary additional treatment,

(e) setting up closed cycles of water supply with local waste-water treatment,

(f) revealing the potential for new advanced water use systems in the most water-consuming technologies (e.g. evaporating, cooling for furnaces).

(g) setting up systems of water recycling in water deficient area of the region.

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19 Water resource series No.54, United Nations, New York, 1981 (pp.142-148).

20 Guidelines for the preperation of national master water plans, "Water resources series" - No.65, United Nations, New York, 1989 (p.145).

Determination of the admissible waste - water load on water courses was a problem of great concern in industrial enterprises. In order to maintain river water in good condition, it was essential that the concentration of pollutants in water bodies should be kept below the maximum admissible level. Longterm planning of waste-water disposal with regard to the maximum admissible concentrations was a very complicated task. Therefore, it appeared reasonable to set criteria for the anthropogenic load on a water course by the main pollutants.

Thus as a whole, planning of water use in industry in the region was given to the balanced development of water supply and disposal systems, which did not decrease the quantitative and qualitative indices of water use.

MASTER PLANS OF MULTIPURPOSE WATER RESOURCE MANAGEMENT (in 1980s)

The master plan approach to water resource management made an attempt to outline solution for meeting existing and future demands for water in Soviet Central Asia. It defined development needs, over a reasonable planning horizon and described paths to be taken to achieve the ultimate solution.

Objective and Goals of Master Plan:-

General basin and territorial master plans in the former Soviet Central Asia were launched in 1980s by Central Soviet Government for multipurpose water use and conservation. Referred as the master water plan it aimed at outlining major water management activities to meet the anticipated water demands of the population and economic sectors, as well as for conservation purposes and the abatement of hazardous impacts. The general master water plan presented a water management basis for the national master plan on the development and allocation of productive forces in the former Soviet Central Asia, for sectoral development plans and territorial development plans.[21]

Basin master water plans were detailed for basins of rivers and other water bodies, based on the main provisions of the general master water plan.

Territorial master water plans in Soviet Central Asia were formulated for economic regions of the Union and Republics, territories and distircts, based on the provisions of the general and basin master plans.

Master plans for multipurpose water management in Union and all the Republics in the region included;

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[21] Water resources series - No.65, United Nations, New York - 1989 (pp.103-104).

- a general master plan for multipurpose water use and conservation,
- Basin master plans for water bodies, the multipurpose use and conservation of which was referred to the relevant authority in the former U.S.S.R. and Soviet Central Asian Republics.
- Basin master water plans when a basin was situated on a territory of two or more Republics as well as when a basin was situated on a territory of one Republic but the anticipated measures might have changed the water supply conditions in the areas of other Republics.
- Territorial master water plans when changes in water supply of one or two Republics were envisaged.

Master plans were being formulated by the U.S.S.R. Ministry for Land Reclamation and Water Management, with the assistance of the USSR Power Ministry as well as specialized institutions of other ministries and agencies.

Long-term and annual programmes for the development of master water plans were compiled by the U.S.S.R. Ministry for Land reclamation and water management which considered the motions of republican councils of ministers, approved them and agreed with the

State Planning Committee of the U.S.S.R. (Gosplan).[22] All union master plans were submitted to the Gosplan by the U.S.S.R. ministry of Land Reclamation and Water Management, agreed upon with the Gosstroy (U.S.S.R. State Committee on Construction) and then authorized by the Gosplan. Soviet Central Asian master water plans submitted by Central Asian republican water management agencies were authorized by the Councils of Ministers of Union and Republics or their Gosplans.[23]

The formulation of master water plan was based on following documents:-

- Government programmes and guidelines aimed at the solution of economic and social problems for a long-term period.
- A comprehensive programme of scientific and technological progress for 20 years and scientific forecasts.
- Concept of development and allocation of productive forces of the U.S.S.R. for a planning period.
- Water demands from republican ministries, agencies and councils of ministers outlined in accordance with the

22 Natural resources/water series No-21, United Nations, New York (1988), pp.30-31.
23 Natural resources/water series No.21, United Nations, New York (1988), pp.36-37.

approved alternative of the development of sectoral and territorial master plans.

Master plan was used for preparing draft guidelines for economic and social development in Soviet Central Asia. Lists of authorized construction projects were designed within the five-year planning period. Master Plan served as an initial data base for conducting feasibility studies for the construction of water projects.

The measures outlined in master plans aimed;

- At the rational use and conservation of water, based on advanced manufacturing technology,
- Application of water processes,
- Reduction of consumptive water losses in irrigation and water supply system,
- Stream regulation,
- Interbasin water transfers,
- Reduction of untreated waste water disposal,
- Alleviation of inundations and water logging in settlements, agricultural areas and other projects.

Practices for Formulation of Master Plans for Multipurpose Water Management:-

Master plans were formulated for a period of not less than 15 years. Data from the state water cadastre, the inventories of the U.S.S.R. State Committee of Hydrometeorology and Ministry of

Geology were being used in assessing surface and ground water resources and design characteristics of water resources development projects. Additionally, for major water projects, surveillance data was also used.[24]

The compilation of master water plans began in the first year of XIth five-year plan period and was completed in the third year of the successive five-year plan period.

Master Plans were evolved into three stages:-

(1) First stage - During the first quarter of the first year of XI five year period, the Union Ministry for Land Reclamation and Water Management collected information from the sectoral master plan of ministries and agencies of the central and from Central Asian territorial master plans on production and allocation of consumptive water uses of the republican councils of ministers.

(2) Second Stage:- Data was collected for water usage and consumption, disposal of waste water by categories and pollutants discharged into water bodies, flow regimen and released on an areal/basin basis.

(3) Third Stage :- In this concluding stage, the final drafts of the master plans were furnished. In the third quarter of the third year of the five-year plan period, the plans were approved by the

[24] Water resources series, No.65, United Nations, New York - 1989 (pp.104-105).

U.S.S.R. Ministry for Land Reclamation and Water Management, agreed with the councils of ministers of Union Republics, U.S.S.R. ministries of power, health and fisheries, the state committee on construction and submitted to the state planning committee for authorization in the fourth quarter.

Basic Problems of Master Plans:-

Water management issue in Soviet Central Asia was closely interconnected with the main frame of socio-economic development and nature conservation. The assessment of ecological and socio-economic efficiency of planned water conservation measures had been made in the "long-term programme of conservation of natural environment and rational use of natural resources in Soviet Central Asia even up to 2005.

The conservation of natural environment was envisaged through :-

- Selection of sites and delineation of boundaries for reclaimed area, allocation of organisational, social and management undertakings.
- Application of advanced techniques for drainage, irrigation and application of fertilizers, technology and materials and automated control facilities.
- Measures to reduce the negative impact of reclamation and water management on the environment (control of

the groundwater table on adjacent areas, waste water treatment, use of irrigation return water, equipment of headworks with fish-protection devices etc.)

- Preservation of valuable and unique water bodies against deterioration caused by human activities or a combination of adverse natural factors.
- Promotion of measures to improve fertility of reclaimed areas, wind and water erosion control, as well as protection of economic projects (industrial, transport, agricultural etc.) from hazardous impact of water (flood control, mud flow control).

In feasibility studies on water management, the following objectives were kept in view by the Planning Commission of the former Soviet Union.[25]

- Improvement of the ecological feasibility compared with previous periods (extensive development and large scale nature transformation projects).
- Optimization of water use limits (taking into account water saving and waste free-technologies, optimal irrigation rates etc.) and effective control over their accomplishment.

[25] Water resources series no.65, United Nations, New York 1985 (pp.105-106).

- Improvement of the methodology used to obtain relevant data on streamflow and water use.
- Elaboration of techniques for water quality forecasts in compliance with measures necessary to maintain standard water quality of natural sources.
- Improved methods of compiling water management budgets differentiated by natural zoning and comprising both qualitative and quantiative characteristics of water.
- Development of optimization techniques for water use allocation for various purposes, taking into consideration the technological, ecological and economic factors and their priorities in concrete conditions.

Land Reclamation and water resource management:-

In view of the new strategy of natural resources usage, radical changes had taken place in planning for the highest water consuming sector such as irrigation and related water management activities.

The future priority trend in land reclamation was characterized by the rehabilitation/improvement of reclamation system and the increase of fertility in irrigated areas. An assessment of irrigated and drainage lands had been carried out, taking data from the indicative reclamation inventory (1986) and the inventory of irrigated and Drained Lands (1987). In the assessment, different characteristics were considered: the groundwater table and salinity, salinization of irrigated lands, erosion potential, degradation of the fertile layer, the water regime of drained lands, bush cover, wind erosion effects and acidity.[26] It was planned to update the data on the status of reclaimed lands, particularly through the broader application of remote sensing.

An analysis of the status of reclaimed lands was done to take necessary action for the improvement of usage and conservation of soils. The actions included construction of drainage, levelling and leaching, gypsum application, erosion control, landscape management, measures for rehabilitation of deteriorated irrigation soils as well as appropriate activities on drained lands. Simultaneously, the technical level of the reclamation system had been evaluated and conclusions drawn concerning their modernization.

Following works were envisaged in Soviet Central Asia.[27]

- remodelling of irrigation network,
- construction and remodeling of collector and drainage networks (12%),
- capital levelling (4%),

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[26] Natural resources / water series No.21.
[27] Water resoruce series, No.65, U.N. New York - 1985 (p.106).

- improvement of water supply (4%)

The tentative scale and measures of the planned improvements in major irrigated zones of Soviet Central Asian basins of Amu-Darya and Syr-Darya rivers was presented as follows:

Table - 24

Plans	River basin	Improvement of irrigated area
I Comprehensive rehabilitation of irrigation network	Amu-Darya	1.2 Million ha
	Syr-Darya	1.5 Million ha
II Rehabilitation of collector and drainage network on area not subject to comprehensive rehabilitation	Amu-Darya	.85 Million ha
	Syr-Darya	.80 Million ha
III Rehabilitation of collector and drainage network on area not subject to comprehensive rehabilitation	Amu-Darya	.52 Million ha
	Syr-Darya	04 Million ha

Source :- Water resource series No-65 (1989)

The accomplishment of these measures on a national scale helped to reduce the water consumption in irrigation in the whole of Soviet Central Asia.

<u>ARAL SEA WATER MANAGEMENT POLICY:-</u>

The Aral Sea, world's fourth largest lake, located in a depression in the Turan plain is fed by two major rivers, the Amu-Darya in the south and the Syr-Darya in the north. The combined hydrological basin of these two rivers has a total area of about 1.9 million km^2. The average annual renewable source of water resource in Aral Sea basin was estimated to be $115.6km^3$ of which 78.46 km^3 is in the Amu-Darya basin and $37.14km^3$ in the Syr-Darya basin.

Before 1960, the level of the Aral Sea was more or less stable. Its surface area was more or less stable. Its surface area was about 66000 km^2 and its volume was about 1060 km^3. The combined average discharge of the Amu-Darya and Syr-Darya rivers to the sea was about $47.50km^3/yr$ to which could be added 5to6 km^3/yr of ground water inflow 5.5- 6.5km $^3/yr$ precipitation over the sea.[28]

The Aral Sea level was then fluctuating at around 50-53m above sea level. The difference between the internal renewable source of water resource of the Aral Sea basin, estimated at 115.6 km^3/yr and the necessary discharge to the sea for a stable water balance, estimated at $47\text{-}50km^3/yr$, was available for use in the basin , i.e. about 65.6 - 68.6 km^3/yr. But the inflow of water into the Aral Sea was declining since the 1960s and it has been progressively drying because of increased withdrawals of water for irrigation from its two tributries, the Syr-Darya and the Amu-Darya.[29]

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[28] Soviet Geography, Vol -xxiv No. 5 1983 (pp. 17-25).
[29] Water Resource Management and policy, Central Eurasian water crisis by I.W. Kobori and Michael H. Glanitz. United Nations university press Tokyo - New York - 1998.

In the 1960s the Soviet government policy assigned Central Asia the role of raw material supplier, notably cotton. This caused the expansion in the arable land, which required irrigation due to the arid climate prevailing over the lower reaches of the Amu and Syr-Darya basins. The development of irrigation in the Aral Sea basin was spectacular, from about 5421 thousands of ha. in 1950 which increased upto 7191 thousand hectares in 1979 (See Table No.3). The population increased from 22,977,000 in 1959 to about 32,804,000 in 1970 and now in 1996 the total population of the region has increased upto 54, 588,000. See Table (no.6).

The total water inflow into the Aral Sea from Amu-Darya and Syr-Darya reduced form 58.8 km^3 in 1960 to 18.9 km^3 in 1978, of which more than 90% for agricultural purposes resulted in the disruption of the prevailing water balance in the basin.

The following date shows the water inflow into the Aral Sea by Amu-Darya and Syr-Darya from 1960 to 1978.

Table - 25

INFLOW INTO THE ARAL SEA

(In km^3)

Years	Amudarya (at Temirbay)	Syrdarya (at Kazalink)	Total
1960	37.8	21.0	58.8
1962	29.1	5.7	34.9
1964	33.1	14.9	51.4
1966	33.1	9.5	42.6
1968	28.2	7.2	36.1
1970	28.7	9.8	38.6
1972	15.5	6.9	22.4
1974	6.2	1.9	8.1
1976	10.3	.5	10.8
1978	18.9	–	18.9

Source :- Borovskiy V.M, the dying of the Aral Sea and its consequences Soviet Geography vol. X No.5 1980.

The huge irrigation development and reduction in the water inflow into the Aral sea caused the average sea level to decline from 53.4 m. in 1960 to 48.3m in 1976 and 36.8 m in 1994. Average are was reduced from 66,900 km^2 in 1960 to 55,700 km^2 in 1976 to just 31,938 km^2 in 1994. The average volume declined form 1090 km^3 in 1960 to 763 km^3 in 1976. While average salinity increased from 10g/l in 1960 to 35g/l in 1976.

The data of changing level of Aral Sea, average area, average volume and average salinity shows the reality.

Table - 26

CHANGES IN ARAL SEA

(1960-2000)

Years	Average level (m)	Average area (km^2)	Average volume (km^3)	Average Salinity (g/l)
1960	53.4	66,900	1090	10
1971	511.0	60,200	925	11
1976	48.3	55,700	763	14
1994	36.8	31,938	298	735
2000	33.4	25,217	212	760

Source :- Kobori was and H. Glantz Michael, Water resource management and policy Central Eurosian water crisis Aral and Dead Sea united nations university press- 1998.

The given map also shows the real picture of levels of Aral Sea from 1960 to 2000.

The reduction in Aral sea level, area, volume and increase in the salinity and increase in the cotton monoculture area created a negative impact on environment, ecology and health in the region. The climate modifying function is lost. The climate around the sea has changed, becoming more continental with shorter, hotter, rainless summers and longer, colder, snowless winters. The crop growing Season has been reduced to an average of 170 days per year. Desert stroms became frequent, occuring on more than 90 days a year. Communities living near the Aral Sea started facing appalling health conditions. The drinking water supply became too saline and polluted. The high contents of metals such as strontium, zink and manganese caused anaemia. Kidney and liver diseases increased and infant mortality rate became highest. Aware of the above problems in the 1980s, the Soviet government decided to develop a water resource master plan for Aral Sea basin:-

Water Management in Aral Sea basin:-

The principle of strict limitation of water resources among the riparian Republics was adopted. Decision was taken by the Ministry of Water Resource Management of the Soviet union in July 1984 for the Syr-Darya waters and in March 1987 for the Amu-Darya waters. Two Basin Water Organisations (BWO) were established to operate and maintain the main hydraulic infrastructures and to monitor water usage. During the glasnost period of Mikhail Gorbachev in mid-1980s, the Aral Sea water management attracted spatial attention of policy makers and international community. The Gorbachev government gave attention to rationalization of water use in the Aral Sea basin.

The rationalization of water use was based on the comprehensive analysis of regional social and ecological factors. The scientists adopted the system analysis methods to address the problem of the optimal distribution of water resources. Regional geographical information system (GIS) and watershed management was launched.

Water Supply Management:-

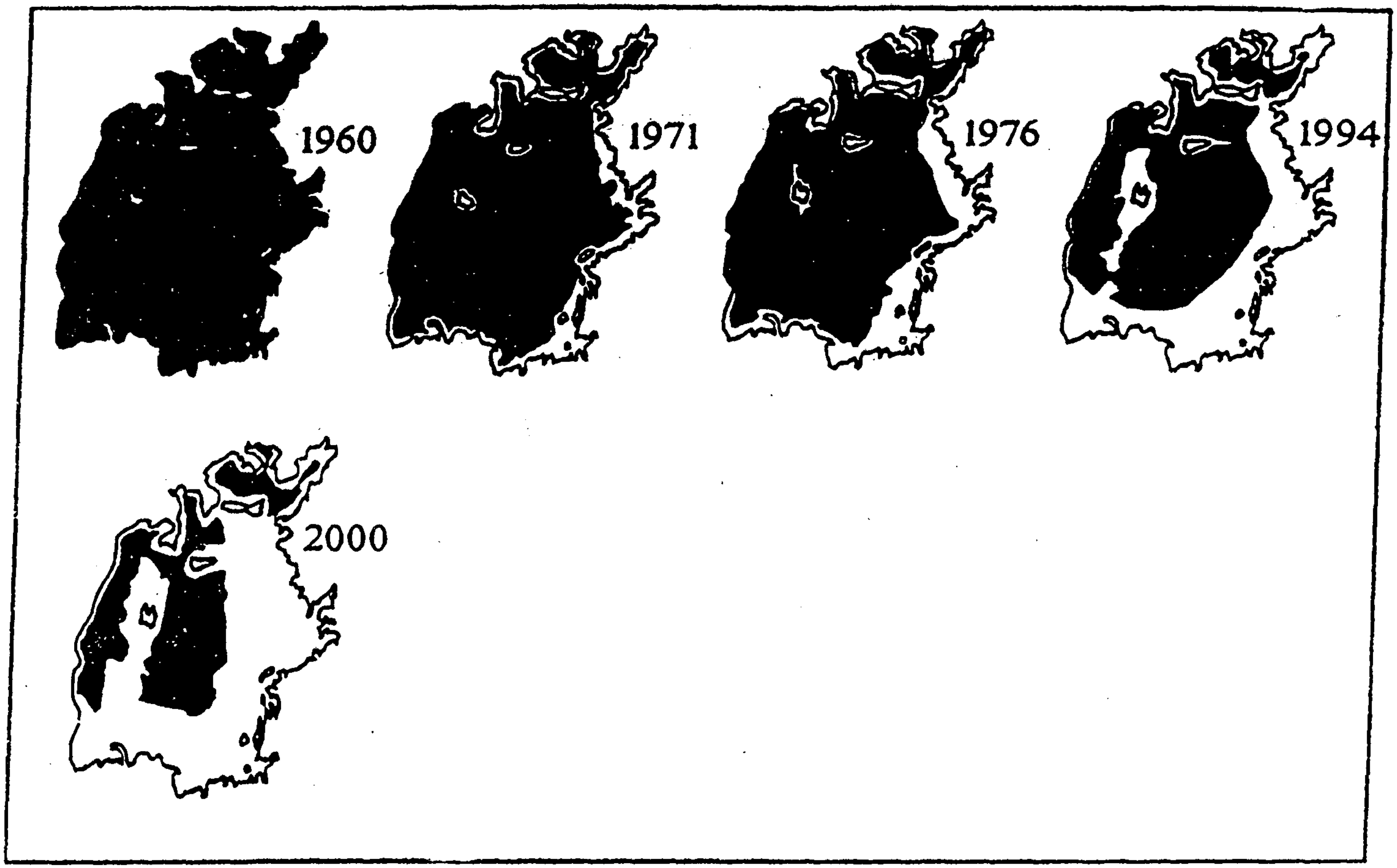
The Soviet central government decided to solve the Aral Sea water problem through water supply management. Central government made a plan of diversion of water from Ob river to the Amu-Darya through 2200km. long canal or from Volga river to the Aral Sea. The government introduced more salt-tolerant crop in the Aral Sea river basin area. To decrease the over usage of water resources of Syr-Darya and Amu-Darya for irrigation government launched a plan of re-use of agricultural drainage water.

Water demand management:-

Government decided to focus on demand management of water resource in Aral Sea basin on the basis of cost management of water. The programme was aimed at reducing the water withdrawal per hectare but the primary objective was to satisfy crop water requirements.

FIG-20

DESICCATION IN ARAL SEA



SOURCE:- PHILIP P. MICKLIN, " DESICCATION OF THE ARAL SEA : A WATER MANAGEMENT DISASTER IN SOVIET UNION, VOL· 241, SEPT- 2, 1989, PP, 1170-76

It was estimated that at least 73km^3/year of water would have to be discharged to the Aral Sea for a period of at least 20 years in order to recover the 1960 level of 53m above sea level.[30] Government also launched the water quality management plan in the region. The water quality problems increased from upstream to down stream due to increasing salinity and practice content of agricultural return flow.

Thus there were number of regional and national plans formulated for Aral Sea water management but none became sustainable. All the management plans have been abandoned with the disintegration of the Soviet union.

The overall planning policy of water resource management in the region was based on both over-consumption and conservation majors. Inter-basin and inter-republican water management policy was based on over utilitarian managerial approach. While automated management, re-cycling of water resource management, master plans of water resource management etc. were based on rational utilitarian and conservation managerial approach. But these plans were still not capable to check the decline of Aral Sea water level as well as the total demand of water for increasing irrigated land and urban

[30] Kobori Iwao and H. Glantz Michael, Central Eurasian Water Crisis: Caspian, Aral and Dead Seas, New York - 1998 (62-65).

industrialization. So there was a need to divert perennial river's water from Siberian U.S.S.R. to Soviet Central Asian region.

CHAPTER - IV

SIBERIAN RIVER WATER DIVERSION SCHEME

The problem of supplying water resource in Soviet Central Asia became a subject of acrimonious polemics that divided specialists and general public into two irreconcilable camps. One view was that the region's water resources are nearly exhausted and therefore supplementary water from other areas is urgently needed. Without this an ecological catastrophe and economic crisis are inevitable. The other view was that Central Asia is quite capable of solving its own water problems, and they that there is need to use water resources rationally, economically and in a technologically sensible manner. To put the debate into perspective, it was pointed out that most of the former Soviet Union's water resources (84%) are concentrated in sparsely settled eastern regions of the country. The southern zones which have 80% of the population, have only the remaining 16% of the water resources.

On the other hand due to increasing population and increasing land area under irrigation the demand of water in Soviet Central Asia was steadily rising. Further the unlimited expansion of cotton area in the region was creating a direct stress on Aral Sea water basin. According to studies conducted in 1970, in a ten-year period the Aral Sea basin provided 85 billion cubic meters of water for effective irrigation, while another 100 billion cubic meters of water were lost through evaporation and diversion to canals. This caused 7 meters fall of Aral Sea, salinisation of water and soil was creating ecological problems from 1965 to 1984.[1] To restore the existing land and water potential in the Aral Sea basin of Central Asia, the Soviet government and planners supported the idea of first camp of specialists and public group to supplement the Central Asian water with resources from other regions. In this view, the solution was to go beyond the Amu-Darya and Syr-Darya basins by constructing canals to delivert the Siberian river's water into the Soviet Central Asian region. This idea was translated into a plan that acquired enormous importance in public life in the 1970s and 1980s not only in Central Asia but also in the former U.S.S.R. as a whole.

The phrase "project of the century" was used often by the Soviet press to describe the plans to divert the Siberian rivers to Soviet Central Asia.[2] The water was to come from the Ob river (from the point at which it is joined by the Irtysh River) and be directed over a canal through the Turan lowlands to the Amu-Darya. The main canal for water diversion (2200 kilometers in length) bisected the arid lands of the semidesert and desert areas of Kazakhstan and Central Asia, permitting irrigation.[3] The peculiarity of the project was that water was taken from a northern zone for diversion to southern one.

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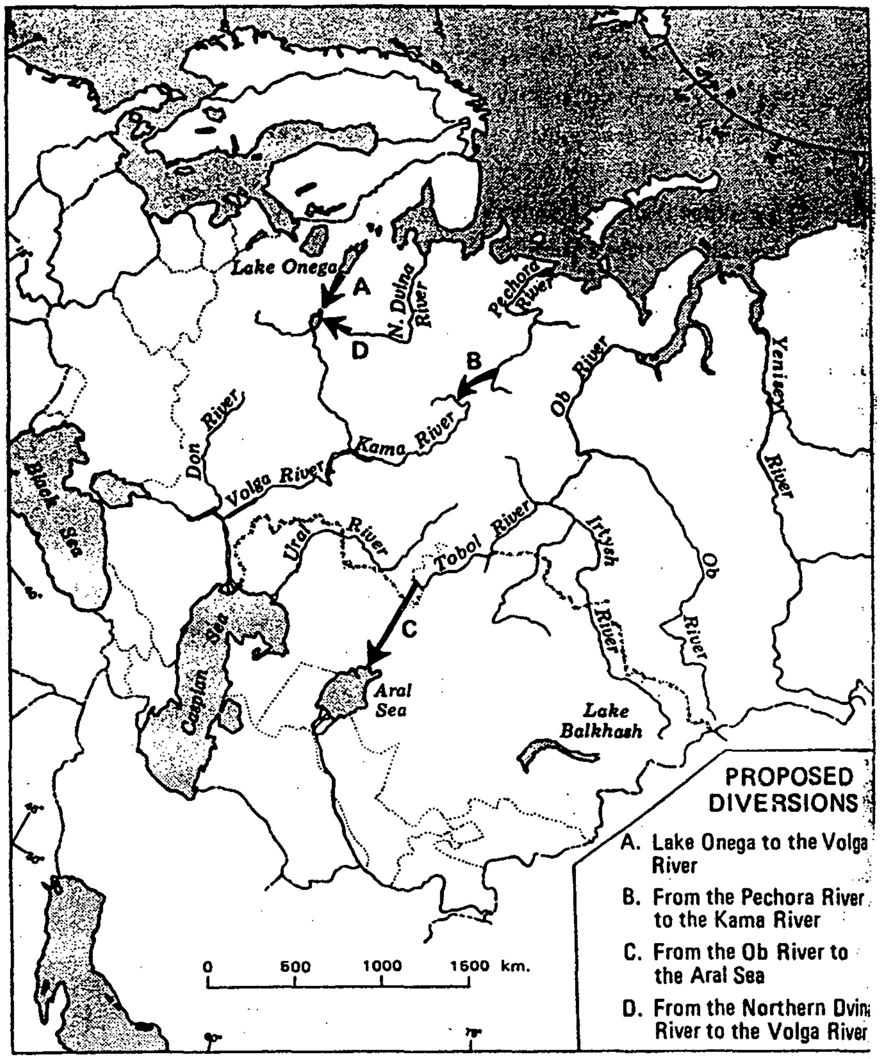
1 Ekonomik izhizn - 1972, no-4 (pp.53-54).
2 Literaturnaia Gazeta, 10 March, 1982 (pp.11).
3 Soviet Geography Vol.-XXVI, No-9, 1985 (pp.728-729).

FIG - 21.

MAP OF
PROPOSED SIBERIAN WATER DIVERSION SCHEME



SOURCE:- LODOLPH, PAUL E., GEOGRAPHY OF THE U.S.S.R - 1990 (P-118).

Consequently, if even a small volume of water was diverted, the impact could be felt as far as the Kara Sea. Hence, the main question was whether the harm inflicted on northern areas will be outweighed by the gains achieved by supplying additional water to the southern region. In addition, this water diversion was portrayed as more cost effective than better use of water resources already at the disposal of the region. The proponents of the project argued that:-

(i) Even if various steps are taken to increase the use of regional water resources (including reconstruction of the existing irrigation system), by 1995 (or by 2000, according to other estimates) the water resources of the Aral Sea basin will nevertheless by exhausted. Thus any further expansion of irrigated land would be impossible and the construction of a canal is absolutely necessary.[4]

(ii) The proponents also argued that the moderate diversion of water from Siberian rivers (some what more than 6% of the water flow in West Siberian rivers) will not have any appreciable influence on the environment of Siberia or the ice flows of the Arctic ocean or on agricultural conditions in the southern areas of Western Siberia, but will yield an enormous profit in the form of an upsurge in agricultural production in Central Asia. According to such calculations, the construction of the canal

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[4] Ekonomika I zhizn - 1984, No-8 (pp.8-9).

will be extremely profitable, paying back its investment in ten years.[5]

But the opponents of the project offer radically different perspective. They opposed the scheme on the basis of ecological and other scientific consequences which causes the end of the scheme in 1986.

BACKGROUND OF THE SIBERIAN WATER DIVERSION SCHEME

The scheme to construct a canal from Siberia to Central Asia has a 100 years history. In the 1870s a professor at Kiev University, I. Demchenko, published a book entitled the "Flooding of the Aral and Caspian Lowlands for the Improvement of the Climate in Surrounding Areas", proposing the diversion of Siberian waterways to Central Asia.[6] Even at that time the author foresaw the possibility that water from the Amu-Darya and Syr-Darya would not be sufficient to irrigate the millions of hectares of fertile lands in the Central Asian region, that for lack of water, would otherwise remain useless.

Interest in this scheme intensified after the Bolshevik revolution. Proposals to redirect Siberian rivers toward Central Asia were put forward by D. Bukinich in 1920, N. Botvinkin in 1924, V. Monastyrev and Z. Kirilets in 1927 and others. All these proposals suggested damming the Irtysh and Enisei Rivers and then directing

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[5] Literature gazeta, 10 March 1982 (p.11).
[6] Rumer, Boris Z. (1989) Sov. Central Asia "A Tragic Experiment", London (pp.86-87).

the water (through the force of gravity) over the Turan low land to Soviet Central Asia. And the proposal offered in 1938 by A. Miller - Shulga sought to overcome the watershed through the use of pumping stations at a height of 30 to 50 meters.[7] In the late 1940 Gidroproekt, the leading Soviet research and design center for hydroelectric construction, conducted economic research on the problem and concluded that the construction of a canal would bring extraordinary economic advantages. Concretely, Gidroproekt proposed to construct an artificial waterway that would redirect one-sixth to one-third of the water flow of the Ob, Irtysh and Enisei rivers to the arid territories of Soviet Central Asian region.

There were two basic concepts for effecting the water diversion by means of gravity over a natural incline and by means of pumping stations. The latter method required immense expenditures of electrical energy, roughly equal to the capacity of the Krasnoiarsk hydroelectric powerstation, the most powerful hydroelectric station in the USSR and one of the most powerful in the world. The gravity approach did not require any significant consumption of energy, but its realization required the creation of water reservoirs of such magnitude (to create the requisite downward pressure) that vast areas of western Siberia would be under water along with oil and gas deposits, the majority of population points, industrial enterprises,

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[7] Ekonomika I Zhizm, 1971, No.2, 15.

agricultural resources and railways. The gravity approach was rejected on these grounds and all further pursued some kind of mixed variant, partly involving the use of the natural relief and partly relying on the use of pumping stations. In the post-war era, interest in the Siberian water diversion scheme and work on its development was intensified by the Soviet government and special attention was given to the scheme through various plans and proposals.

SOVIET PLANS FOR THE DIVERSION SCHEME

Till the death of this scheme over the last several decades, three main initiatives had been brought forward by the Soviet leadership.

(1) **The Khrushchev Plan**:-

At a plenum of the Central Committee in 1961, Nikita Khrushchev advanced the idea of irrigating the arid lands of the south both to solve the food problem and to increase cotton production. Khrushchev, characteristically, envisioned irrigation as a panacca for all the failures of Soviet agriculture as the most reliable means to obtain guaranteed harvests.[8] At the time Khrushchev was enthralled by the idea of irrigation which would exploit the lands of Soviet Central Asia, where there was more susnshine but not enough water. To his mind expanding the amount of land under cultivation was the most effective way to increase agricultural output.

[8] Pravda 21 Jan. 1961 (p.2).

For the conquest of the virgin lands Khrushchev insisted on giving attention to the gigantic project of irrigating the lands in the maximum part of Soviet Central Asia. He argued that realization of this project would help the Soviet Union to satisfy 30% to 40% of the country's needs of grain and also to obtain the required amount of such valuable agriculture products as cotton, rice, corn etc.[9] Khrushehev became exuberant over these plans and proposed to rechannel the rivers from the Arctic Ocean to the south, particularly to Soviet Central Asia.

But the imagination of the Soviet leaders was not limited to the irrigation of land. They were fascinated by the idea of river diversion because they were thinking to obtain a new economically advantageous path from the north of the country to Soviet Central Asia.[10] Khrushchev drew a picture of spectacular prospects for an unprecedented leap in the production of cotton and concluded his speech with the following slogan: "Full steam ahead in the production of cotton."[11] Khrushchev assured his listeners that, although this proposal would demand no less effort and investment than development of virgin lands in Central Asia and Western Siberia, this undertaking nevertheless is entirely within our capacity.[12]

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9 Ibid.
10 Ibid.
11 Ibid.
12 Ibid.

No one made an open rejoinder to Khrushchev. However, his ideas were not and indeed could not be implemented, for valid economic reasons. And Khrushchev himself did not return to these ideas. Other experiments and events detrected his attention from the grandiose scheme to redirect the flow of Siberian rivers towards Soviet Central Asia.

(2) **The Brezhnev Proposal**:-

In 1971, Brezhnev directed the ministry of Reclamation and Water Management to organize research and exploratory work on the diversion of Siberian rivers to the Amu-Darya and Syr-Darya basins. In 1976 the twenty-fifth party congress adopted a resolution to conduct scientific research and on the basis of this to carry out project studies connected with the problem of diverting part of the flow of northern and Siberian rivers to Central Asia.[13]

This formulation which reflected the ambivalence of the leadership toward the feasibility of the whole scheme was quite cautious in several respects. First, it showed a lack of certainty about the economic feasibility of the undertaking. Second, initiative enthusiasm and gigantomania in economic policy were not among Brezhnev's main traits, in contrast to those of his predecessor. Accordingly, the Brezhnev leadership also evaded a definitive decision on the question at the twenty-sixth party congress in 1981 and in

[13] Soviet Geography, Vol.-XXII, No-9, November - 1941 (pp.553-556).

effect, simply reiterated its previous decision to continue scientific and planning studies on the diversion of part of the water of Siberian rivers to Soviet Central Asia.

(3) **The Chernenko Proposal** :-

In this phase important decisions were finally taken to complete the research and preparatory work for the diversion scheme. Chernenko's name was used as a kind of political shorthand, since this expiring figurehead was hardly capable of dynamic initiatives. But a group of highly placed figures, with strong vested interests in the scheme became exceedingly active. They included N. Vasilev (the Minister of Reclamation and Water Management) G. Voropaev (Director of the Institute of Water Problems at the Academy of Sciences) and I. Gerardi (the ranking executive behind the whole project). Reacting to pressure from this group, the Central Committee resolved in October 1984 to complete preparation of the plan to construct a canal from Siberia to Soviet Central Asia.[14] In accordance with this resolution, the ministry of Reclamation and Water Management was to undertake planning of the main canal to complete all exploratory and planning work by 1986.

Thus the whole matter suddenly acquired a completely concrete character. This exploratory and planning work, conducted across the enormous length of the project was an extremely costly operation and

14 Pravda, 27 October 1984, 1.

ecologically more disastrous. It signified an end to lingering doubts and the intention to construct the canal.

Forecast of Possible Impact of the Siberian Water Diversion Scheme on Nature and Climate

The proposal and plan of Siberian water diversion towards Soviet Central Asia had completely concrete character for the overall economic, social and environmental enhancement of the region. But the proposed water diversion scheme became the matter of acrimonious discussion amongst the researcher, ecologist, meteorologists, climatologists, hydrologists, environmentalists and scientiests. They tried to investigate and forecast the possible modification and any changes in energy balance and heat resources. They also forecast the expected changes in the structure of weather types, changes in the temperature and humidity of the air in the zone of diversion area and Aral Sea region, impact on the precipitation environment and atmosphere above Soviet Central Asia.

1. **Forecast of changes in Energy Balance and in Heat Resources:-**

For the estimation of changes in the energy balance and in heat resources of the water diversion course in the region, the appropriate quantitative estimates were derived by the complex balance technique i.e. the combined analysis of equation, heat and water balance of the underlying surface. This was the forecast of the concerned scientists that the projected construction of a network of canals, reservoirs and other water features and the associated draining or flooding of areas will inevitably disturb the natural conditions and properties of the underlying surface. They argued that this will be true in particular of local changes in radiation characteristics (albedo, outgoing radiation) and thus in the heat resources that characterize the maximum possible evaporation during the warm season.

The most significant changes were likely to occur above the open water surfaces of canals, rivers and reservoirs as well as above waterlogged areas, irrigated land and other wetlands. It had been calculated that a reduction in the reflecting capacity of these surfaces will increase energy resources by 20% to 30%.

It was forecast by the scientists that the Siberian water diversion to the arid zone of Soviet Central Asia will produce lands with different levels of moisture - irrigated lands and areas that will be flooded by a rise in the water table. In terms of albedo, five types of underlying surface were distinguished. They are mentioned in the table below:-

Table - 27

Albedo of underlying surface of Soviet Central Asia (in %)

Type	Underlying surface	Albedo in (%)	
I	Water surface of canals and reservoirs.	Limits	Mean
II	Soaked surface of soil after irrigation or flooding & very wet groundwater fed swamps.	10-11	10
III	Wet bog-meadow soils of the light chestnut type, wet loess soils with dense plant cover and dry dark - brown soils after irrigation or watering.	12-18	15
IV	Dark gray soil after irrigation, alluvial meadow soils of river valleys, grassy floodplain swamps.	16-20	18
V	Wet sandy soils, river valleys with green grass, gray-brown soils, irrigated Sierozom, floodplain meadow, lush dense green grass.	18-25	22

Source:- Soviet Geography, Vol.XXII, No-6, June 1982 (pp.429).

Climatologists studied that reduction in the albedo of irrigated and flooded lands will result in a trend towards greater absorption of incoming short-wave radation and, therefore, a positive radiation balance compared with a dryland station. The radiation balance, especially in underlying surface types I and II would increase during the daylight hours (the so-called positive radiation balance) of the warm season, from 44-45 kilocals per 50.cm. per year to 57 kilocals in Type II and to as much as 60 Kilocals in type I.

The climatologists predicted that in the zone of the southward transfer of Siberian water, the increase of the positive radiation balance during the warm season (the sum of daily temperatures above 0° will range from 3.1 Kilocals/sq.cm. (at the lattitude of Kustanay) to 13.5 kilocals (at the latitude of Aral Sea).[15] It had been predicted that with irrigation and pasture watering and the corresponding decrease

[15] Soviet Geography, Vol.XXII, No-6, June 1982 (p.430).

in albedo of the underlying surface, the radiant heat resources in these areas during the irrigation season will increase from 44.7 kilocals/sq.cm. to 47.8 and 50.4 kilocals and the level of maximum possible evaporation will rise from 745 to 797 and 840 m.m in type I surface area mentioned in table. It was also forecast that with a reduction of albedo, the heat energy resources and evaporability during the irrigation season will rise by 7-19% on irrigated land and by 12-13% on reservoirs compared with the dryland level.

It was estimated that the total amount of irrigation water needed to maintain an optimal moisture supply in the roof layer of soil through the warm season will be 1,600 to 3,400 cu. M/ha in wooded steppe and 9,500 to 10,250 cu. M/ha in desert area of Soviet Central Asia.[16] The forecast argued that in view of the shorter growing period, the bioclimatic requirements of plants and the discrete nature of irrigation water applications, the amount of water may be reduced by 30 to 50%. As a result irrigation and flooding caused from a rise in the watertable will increase the loss of heat through evaporation, which would be 36 to 48 kilocals in arid and semairid area. Differences between an irrigated field and nearby dry land at noon would be 4 to 11 degrees c. at the level of the evaporating surface and 1 to 2 degree at the standard height.[17] The

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[16] Lutz Holzner & Jeane M. Knapp. 1987, Soviet Geography Studies in our Times (pp.116-117).

[17] Soviet Geography, Vol.XXV, No.-4, April 1984 (pp.261-262).

climatologist forecast that lowering of the air temperature as a result of irrigation may result in a reduction of heat resources, i.e., the sum of temperatures during growing season, by 200 to 300 degree at a height of 2 meters.

2. **Expected Change in the Structure of Weather Type**:-

The projected transfer of Siberian water towards Soviet Central Asia had an expected impact on the structure of weather types in Siberian region and also in the Soviet Central Asian region. Meteorologists had forecast that this diversion will create major changes in evaporation, radiation, precipitation, overcast, cloudiness etc. in the forest, swamps, dryland and in fertile plain areas in different way. This phenomenon was predicted by O.V. Soromotina, a meteorologist in the Division of Meteorology and Climatology of the Moscow Branch of the Geographical Society USSR.[18] He accounted the view of number of climatologists forecast that the diversion scheme will create following possible changes in the structure of weather in terms of the frequency (%) of weather types in both the Siberian part of Soviet Russia and Soviet Central Asia.

They presumed that due to diversion the frequency of weather will become moderate. In Soviet Siberian region due to this diversion the frequency of hot and dry weather will be increased 2% at Omsk and 0-1% at Tobolsk in the month of July. Cloudiness will change

[18] Ibid.1

around 26% to 28% at Tobolsk and at Omsk it will around 33% to 37%. The precipitation will change around 13% to 15% at Ust-Ishim and 20% to 22% at Tomsk.

Weather change in Soviet Siberian region has been shown in given table:-

Table - 28

Possible Changes in the Frequency of Weather Types in Soviet Siberia in July (in %)

Station	Weather type						
	I	II	III	IV	V	VI	VII
Tobolsk	1	10	22	28	10	11	18
	0	8	27	26	9	11	19
Tyumen	1	12	18	28	12	12	17
	0	11	20	26	12	12	19
Ust-Ishim	1	5	32	34	6	9	13
	-	4	34	32	6	9	15
Tara	1	4	29	35	10	7	14
	-	3	34	30	10	7	16
Tomsk	1	8	24	30	10	7	20
	-	6	29	26	10	7	22
Ishim	1	9	32	26	13	9	10
	-	7	37	22	13	9	12
Omsk	2	15	20	37	8	6	12
	2	15	21	33	8	6	15

Weather Types:-

I. Sunny, very hot and very dry - Sukhovey dry
II. Sunny, hot and dry
III. Partly cloudy
IV. Daytime cloudiness
V. Nighttime cloudiness
VI. Overcast
VII. Rainy

Source:- Soviet Geography, Vol.XXII, No.-6, June 1982 (p.434).

At the same time on the other hand for Central Asian region it was predicted that diversion scheme may reduce the heat impact of swamp drainage. The construction of dam and reservoir in the diversion course will reduce the heat flux in the lower reaches which will diminish the heat content of weather likely to arise in the zone of impact of the heat flux and will enhance the frequency of evaporation fog. Meteorologists predicted that the structure of heat balance is likely to shift towards loss of sun's heat through evaporation (from water surface, well watered irrigated land and lush green vegetation of Oases), the frequency of Sukhovey-dry weather type will increase around 92% at Kazandzhik, 99% at Repetek and only 3% at Gazankuli. It will also affect the cloudiness, precipitation etc. This can be illustrated by given table:-

Table -22

Expected Frequency of Weather Types in July in Soviet Central Asia in (%)

Station	Weather types									
	I	II	III	IV		V		VI	VII	VIII
				No Rain	Rain	No Rain	Rain			
Artem	4	13	60	2	-	3	-	1	-	17
Kazandzhik	92	6	-	1	0	-	0	0	1	-
Gazan-Kuli	3	23	50	4	-	7	2	4	1	6
Aral Sea	49	23	11	8	2	1	1	2	3	-
Kzyl-orda	63	31	1	3	1	-	0	1	0	-
Balkhash	39	39	5	10	2	-	-	1	4	-
Tashkent	58	40	0	0	1	0	0	-	1	-
Repetek	99	1	-	0	0	-	-	-	-	-
Bayram Ali	98	2	-	-	-	-	-	-	-	-

Weather Types:-

I. Sunny, very hot and very dry - Sukhovey dry
II. Sunny, hot and dry
III. Partly cloudy
IV. Daytime cloudiness
V. Nighttime cloudiness
VI. Overcast
VII. Rainy
VIII. Very hot and very humid.

(IV–VI: rain or no rain)

Source:- Soviet Geography, Vol.XXII, No.-6, June 1982 (p.434).

Meteorologists were demonstrating the strong mesoclimatic impact of the local natural setting on the frequency of Sukhovey-dry weather due to diversion. They argued that the impact of seas, lakes and oases are evident mainly in the lower frequency of Sukhovey-dry weather types both over the water surface and in coastal zones of lakes, canals. According to them the impact fades fairly rapidly with distance from the body of water (and even more so with distance from oases). But the impact of the bodies of water goes beyond that. The water bodies would also weaken the intensity of Sukhovey-dry weather. Climatologists obtained the result through observation of Tashkent Oblast, upper Khorezm and middle Amu-Darya oasis that the water weakens the Sukhovey-dry weather. They argued that the Sukhovey-dry weather may be hazardous for cotton (with a daily mean temperature of less than 20% and a saturation deficit of more than 50 m.b.) thus affecting cotton production in southeast Turkman, in western and southern Uzbekistan and in plains of southern Tadjikistan. Throughout the desert zone, most cases of Sukhovey-dry weather would be caused by the transformation of heating.[19]

The division of meteorology and climatology of the Moscow Branch of the Geographical Society of USSR. obtained the frequency of Sukhovey-dry weather intensity which was directly related to water

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[19] Ibid.

use. It was revealed that at Tashkent water use was 4.2 km^3 That's why the intensity of Sukhovey-Dry weather was 0% is Tashkent while at Kyzylkum and Karakum the water use was 0 km^3. So here intensity of Sukhovey-dry weather was 36% and 34% respectively. Similarly the intensity of water use is positively correlated with the weak, moderate, harsh and extreme intensity of Sukhovey-dry weather.

The following data shows the frequency of Sukhovey-dry weather of varying intensity :-

Table - 30

Intensity of Sukhovey-Dry Weather of Soviet Central Asia (in %)

	Intensity in (%)					
Oasis of desert	Weak	Moderate	Intensity	Harsh	Extreme	Water use (km^3)
Tashkent	41	59	0	0	0	4.2
Upper Khorezm	56	40	4	0	0	2.0
Middle Amu-Darya	50	46	4	0	0	1.5
Lower Zeravshan	27	60	12	1	0	1.6
Surkhan Darya	13	69	14	4	0	0.8
Kyzyl Kum	9	37	36	16	2	0.0
Kara Kum	6	31	34	26	3	0.0

Intensity Classes (in terms of vapor pressure deficit in mb.)

Weak - 23
Moderate - 29
Intensive - 40
Harsh - 51
Extreme - 67

Source:- Soviet Geography, Vol.XXII, No.6, June 1982 (pp.436).

Based on this study the climatologists and meteorologists predicted that the proposed diversion scheme would reduce the intensity of Sukhovey-dry weather which would be good for the crops in the region and weather will become moderate at the local level. They forecast that the frequency of Sukhovey-dry weather along the proposed canal route would naturally decline mainly because of the reduction of incoming radiation and increasing impact of cyclonic activity. Due to proposed diversion the newly irrigated land would expand thus affecting the local weather in the desert zone over a short distance. Thus the proposed diversion was expected to change the structure of weather types in both the Soviet Siberian and Soviet Central Asian region.

3. **Forecast of changes in Temperature and Humidity of the Air in the zone of water diversion**:-

Both the climatologists and meteorologists had forcast that the proposed Siberian water diversion scheme will envisage the creation of new irrigation and watering areas in which water applications were likely to modify the water, radiation and heat balances. It was predicted that the sharp rise of evaporation associated with an increase in the heat spent in the process will produce a drop in temperature and an increase in humidity in the ground layer of the air above the oasis and nearby.

The Climatology Department of the Institute of Geography of Moscow calculated possible changes in temperature and humidity in the ground layer of the steppe, semi-desert and desert along the proposed diversion canal. It was predicted that in the proposed diversion canal zone there would be -0.4°C to 0.7°C (in May) and

0.0°C to -0.7°C (in September) change in temperature in the steppe zone. In the desert zone temperature would change around (-1.1°C) to (-2.1°C) in may and (-1.2°C) to (-1.9°C) in the month of September. Similarly in the steppe region humidity of the air would change around 0.6 to 0.9 mb. in May and 0.7 mb. to 0.9 mb. in September. In the desert zone the humidity change would be highest in August - 2.6 mb. to 3.9 mb. and lowest in May - 1.6 mb. to 2.4 mb. The data of expected change of temperature and humidity has been given below:-

Table - 31

Expected Changes in Temperature in Diversion Canal Zone of Soviet Central Asia (in °C)

Zone	Months				
	May	June	July	August	September
Steppe	-0.4 to -0.7	-0.5 to -1.1	-0.4 to -1.4	-0.3 to -1.3	0.0 to -0.7
Semidesert	-0.7 to -1.4	-1.4 to -2.1	-1.6 to -2.3	-1.5 to -2.2	-0.7 to -1.3
Desert	-1.1 to -2.1	-2.1 to -3.1	-2.3 to -3.6	-2.3 to -3.6	-1.2 to -1.9

Source : Soviet Geography, Vol.XXII, No.6, June 1982 (pp.440).

Table - 32

Expected Changes in Humidity in Diversion Canal Zone of Soviet Central Asia (in mb.)

Zone	Months				
	May	June	July	August	September
Steppe	0.6 to 0.9	0.9 to 1.8	0.9 to 2.1	0.7 to 1.7	0.1 to 0.9
Semidesert	1.2 to 1.7	2.0 to 2.7	2.3 to 3.0	2.0 to 2.8	0.9 to 1.7
Desert	1.6 to 2.4	2.5 to 3.4	2.9 to 4.5	2.6 to 3.9	1.7 to 2.6

Source : Soviet Geography, Vol.XXII, No.6, June 1982 (pp.440).

4. **Possible Impact on Precipitation due to diversion scheme** :-

The Climatology Department of the Institute of Geography of Moscow calculated the possible impact on precipitation in Soviet Central Asia, if Siberian waters were also to be used for irrigation in addition to local water. The calculation was based on aerological data for the period of 1961 to 1970. The climatologists obtained slightly larger magnitudes for the moisture content and moisture transfer above the Central Asian plains, including the Aral Sea.[20] They assumed that an additional 200 Cu. Km of moisture a year would enter the atmosphere and that relative humidity would rise by 4% to 7%. As a result climatologists found that in the case of Siberian water transfer in Central Asia, precipitation in the region would increase around 4% to 7%.[21]

According to the study done by climatologists, due to the extra water supply in Aral Sea through Siberian water diversion scheme, the share of evaporation from the Aral Sea would increase to 10 to 12% of the overall moisture transfer in summer. It was argued that some of that moisture would be dispersed and be carried out of the Soviet Union the rest condensing along the mountain slopes and returning to the ground as precipitation in the northern part of Central Asian region. The study showed that the overall impact of the

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20 Ibid.
21 Soviet Geography, Vol.XIII, No.6, 1982 (pp.442).

southward shift of evaporating surfaces on the formation of additional precipitation in the mountains of South Central Asia would be negligable.

It was predicted that the increase in the amount of moisture entering the atmosphere from irrigated fields will cause a decline of temperature gradients and the formation of inversion, which would hamper the development of rising air currents and thus the rise of moisture to the condensation level. This diversion scheme would also cause the origin of additional precipitation thus producing additional runoff in the region.

5. **Forecast of Possible Changes in the Environment** :-

Proposed Siberian water diversion scheme towards Soviet Central Asia became an acrimonious issue among the environmentalists. They predicted that the greatest differences in levels between the Irtysh River and the bottom of the Turgay trough is less than 90m, which is less than 200-250m between the Irtysh river and interfluve plains. They suggested that this difference in slope of the Turgay trough and along the valleys of the principal rivers in diversion course would support the increase of gully growth from north to south. This maximum gully growth in the region would coincide with maximum differential tectonic uplifting affecting the local environment.[22] Along with gullying, this diversion would also

[22] Soviet Geography, Vol.XXVI, No/-9, 1985 (pp.729-731).

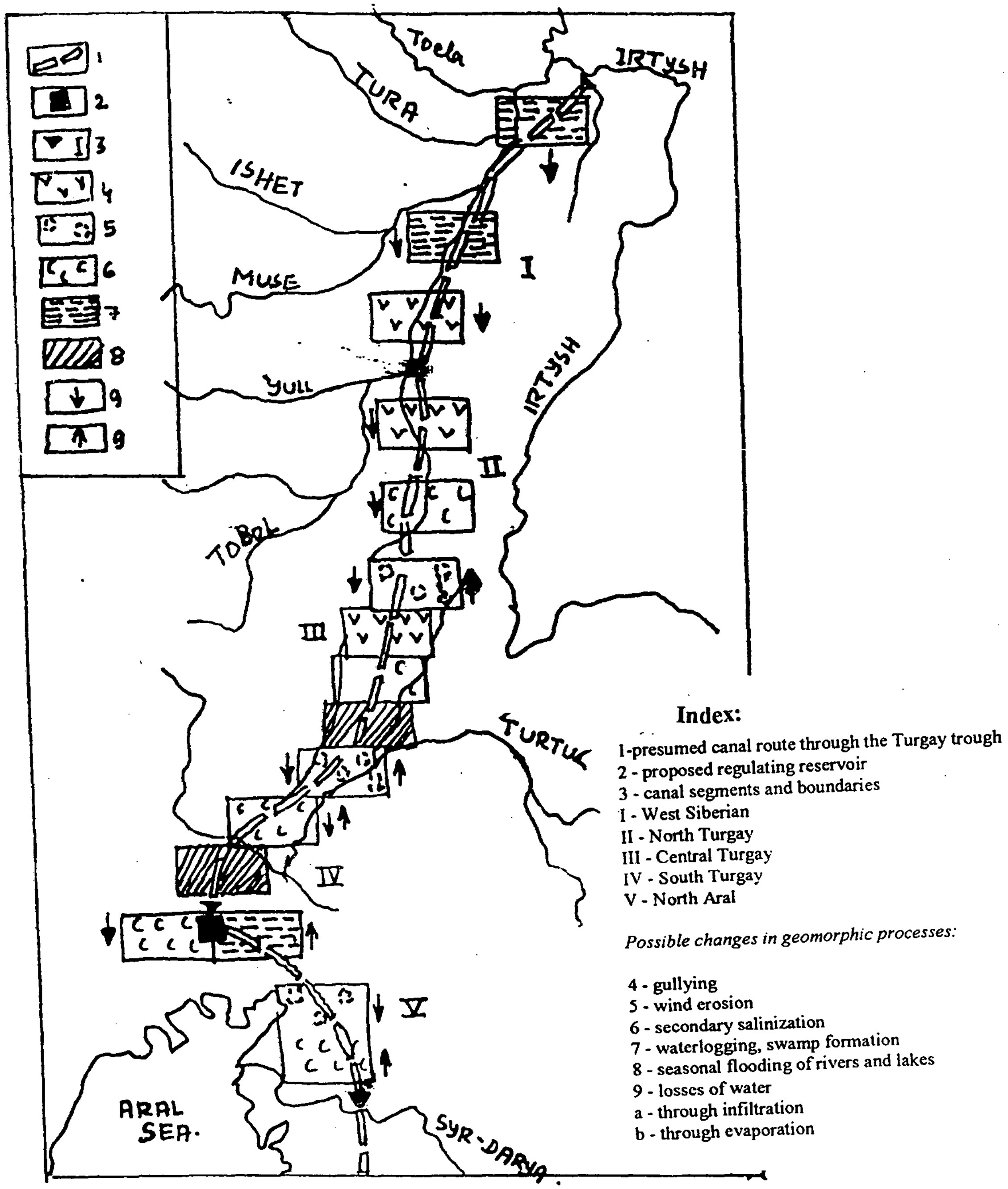
support sheeterosion, rillerosion, weathering, solifluction, slumping, debrisfall etc. creating an environmental problem on large scale.

The eolian activities would be come evident everywhere along the proposed canal route in the form of wind erosion on the agricultural land of the northern Turgay, soil deflation in the sparse plant cover of the sub-arid and arid plains of the Turgay and northern Aral region and deflational, depositional work in the region would create environmental problem. They argued that the local relief of diversion canal region was insignificant and interfluves were poorly drained made up on the surface by clayey loams and clays with a very shallow watertable. This was likely to lead to excessive moisture supply along the canal route which would create water logging, swamp formation and salinization. Environmentalists predicted that this diversion would cause seasonal flooding of rivers and lakes in the lower course of diversion canal area. They also suggested that this diversion would create drastic environmental change by loss of water through infiltration and through evaporation in the southern Siberian region and Central Asian part. The given map shows possible environmental changes along the proposed Siberian water diversion canal region.

Thus the Siberian water diversion scheme had grossely positive and negative possible impact on nature and environment in the short term. But in the long terms it had overall negative impact on

FIG- NO. 22

SOVIET CENTRAL ASIA: POSSIBLE ENVIRONMENTAL CHANGES ALONG PROPOSED SIBERIAN DIVERSION CANAL



SOURCE :- M.YE. GORODETSKAYA, " SOVIET GOGRAPHY VOL- XXII, NO-6 (1982) P. 410-411 environment. On the other hand this exploratory planning work conducted across the enormous length of the project, was an extremely costly operation. Passions became inflamed and finally this Siberian River diversion scheme became a major focus of the Russian nationalist movement.

The Great Siberian River Diversion Scheme As a Focus of the Russian Nationalist Movement

The decision taken by top authorities in Moscow to implement the Siberian river diversion scheme encountered active resistance from the Russian intelligentsia. Under Khruschev and Brezhnev, plans for the diversion scheme evoked mute dissatisfaction among the Russian nationalist elite. By this time, Soviet Union had already accumulated considerable bitter experience from the creation of canals and water reservoirs in European Russia that were economically unjustified and ecologically catastrophic. The white sea-Baltic and Volga-Don canals, the Rybinsk, Tsimliansk and Krasnoiarsk reservoir, the diversion of water from lake Sevan regarded by Armenians as a holy national shrine - all these gave ample cause for alarm at the prospect of the Siberian water diversion southward.

By the late 1970s and early 1980s ecology had become both a popular and a permissible subject of debate. Environmentalists, were not punished for attacks on local authorities and ministerial officials for their criminal behaviour toward nature. Indeed, it even became rather fashionable in the press to demonstrate a concern for nature.

Manifesting concern about "the natural environment of our homeland" gave an outlet for nationalist feelings and established a reputation of civic courage for the nationalist anger to express public opinion.[23] It was also important, from the regime's point of view, to sustain the illusion of a public discussion.

Gorbachev's accession to power inaugurated an unusually vigorous movement to defend the Russian and Central Asian environment and culture by a group called the Russian Party. Indeed, defense of the Russian national idea began to acquire an increasingly aggressive character.[24] In the first few months of Gorbachev's rule, the Russian Party assumed a wait and see position. But as the new leader's intentions remained obscure and the state and party apparatus treated the question as already decided, the opponents of the river diversion scheme took action. Apparently, it came as a shock when the project surfaced in the draft version of "The Basic Directions of Social and Economic Development in the USSR", published in November, 1985.[25] This public reaffirmation of the intent to carry out the project unleashed a wave of criticism in the press. It was all the more easy to raise the issue because the draft for the basic directions offered a contradictory formation of the project.

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[23] Rumer, Boris Z. (1989), Soviet Central Asia, "A Tragic Experiment", London (pp.92-93).
[24] Pravda 11 and 13 Feb. 1987.
[25] Rumer, Boris Z. (1989) Soviet Central Asia A Tragic experiment, London (p.93).

Thus on the one hand it vowed to improve the scientific foundations of the plan, but on the other it hastily sought to expand the work related to the diversion of the rivers towards Central Asia. A series of critical comments was published in journals and newspapers by United Nations expert on environmental affairs and local Russian nationalists, journalists and writers.[26] Politicians and academicians had also criticised the project. Thus the project provoked widespread indignation in the Russian population and intense outburst of popular sentiment that the leadership evidently could not ignore.

At the beginning of late 1985 the arguments against the project changed. Earlier critics relied on ecological arguments and appeals to patriotic feelings. But now they claimed that the project was economically unsound. Thus a series of articles was published on the subject of "the price of water."[27] Questions were raised in the articles that the government would spend billions of rubles on the project, yet in calculating its economic effectiveness for irrigated agriculture, it treated water as a free good.

The struggle of Russian Party against the proposal reached its culmination at the Writers' Congress in July 1986. Passions became highly inflamed. All the civic emotion that for years had been denied any kind of expression suddenly came out into the open, in the public

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[26] Pravda, 30 December, 1986.
[27] Pravda 12, Feb. 1986.

statements of Russian writers. Now writers attacked the river diversion project and its proponents with furious denuciations.[28] Politicians were supporting the repudiation of the Siberian water diversion in the context of the great Russian and anti-Muslim tendencies in Soviet nationality.[29]

Thus the rise of an unprecendented battle of ideas of national and economic interests and scientific conceptions led to the abolition of the Siberian water diversion from north to south in the Soviet Central Asian region.

<u>End of the Siberian Water Diversion Scheme</u> :-

Apart from the nationalism, there were also very good reasons for not to trust the judgement of designers and officials of the Ministry of Reclamation and Water Management who composed the main core of protagonists for the project and who lobbied on its behalf in Moscow. Opponents of the project offered a radically different perspective. They pointed to the inadequate research on the national ecological consequences and also highlighted the vested interests of the Ministry of Reclamation and Water Management. Critics argued that the water resources of Central Asia are used with such extraordinary inefficiency that the irrigated lands don't yield the appropriate return. As such the enormous investments for the project

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28 Ibid.

29 Ibid.

were not economically viable. Indeed the evaporation loss through the movement of water across an open canal (together with its absorption into the soil) would be extraordinarily great.

Not only the opponents but many prominent Soviet scholars argued that the project lacked a sound scientific basis, thereby raising serious hydrologic, ecological and economic questions. It was not clear as to, what share of the water diverted from the Ob would actually reach its destination, how many minerals this water will contain, how the flora and fauna of cold Siberian water would react to the hot climate of the desert or what would be the construction of the canal.

The water diversion also embodied significant potential global ecological problem. One of the most serious problem was the potential change in the ice cover of Kara sea resulting from reductions in the volume of Ob river discharge. It was realized that this would create a world - wide climatic repercussion. In the meantime most popular contemporary Russian writer, Valentin Rasputin writing on behalf of group of writers opposed the river diversion scheme. He, demanded that -

> "we, a group of Russian writers who will be joined by writers of other Republics, appeal to the Politburo and personally to Mikhail Gorbachev to authorize an investigation of the situation that has developed with repsect to the northern rivers and Lake Baikal and to

make a decision in the interests of the entire people - and not specific administrative organs."[30]

Soon after, at the Writers' Congress meeting, presided by Gorbachev and various writers including Rasputin, Gorbachev voiced his own support in favour of the opponents of the water diversion project.

Finally, on August 16, 1986 came the announcement that the politburo had deemed it expedient to cease work on the "project of century". Four days later the Central Committee and the Council of Ministers published a resolution on the cessation of work to divert part of water from the northern Siberian rivers south-ward in Central Asia, with a specific instruction that "Gosplan and Ministry of Reclamation and Water Management eliminate the plan for 1986-1990 the assignment to complete the aforementioned work."[31]

Thus the "project of the century" or the Siberian river water diversion scheme was abandoned with the disintegration of former Soviet Union.

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30 Ibid.

31 Pravda, 20 August 1986.

Chapter - V

CONCLUSION

Soviet Central Asia constitutes one of the arid zones of the planet has limited and unevenly distributed water resource in terms of present and expected future demand. The acquatic ecosystem of this region exists in the limited water of Rivers, Lakes Marshes, Soil moistures and groundwater. Limited supply of water through precipitation Creates Complex interrelation between surface water and the groundwater in the region. Perennial rivers originating from the snowy mountains are only the permanent source of water in whole Soviet Central Asia. Lakes, Groundwater and Glaciers are the Complimentary supplying agents of water resource.

In the Pre-Russian period water resource management was based on ancient Custom and the Shariat. Water was mostly used in subsistance agriculture and the management was in the hand of territorial Khanates authority. The nature of water resource management was non-exploitative an eco-friendly.

With the assumption of power by the Soviets, the water resource management policy in the region was modified by the Union's Agriculture and Water-Resource Ministry due to the increase in irrigated agricultural land, infrastructural development and industrial urbanisation. The Central Asian agro-climatic conditions were most favourable for cotton cultivation in the Former Soviet

Union(F.S.U.). So to make the Union self-reliant in cotton production and to supply the demand of cotton to textile industries in the north western industrial areas, the Soviet Government followed the monoculturisation of cotton in Soviet Central Asia right since the 1920s which policy has been continuing.

Increase in the irrigated land area now became a fundamental natural constraint in the region. The Government policy became exploitative, the use of laky and rudimentary water delivery systems in the field started for uneven and excessive irrigation. Water was mainly used in agriculture sector dominated by cotton crops. For the proper distribution of water resource Soviet Government launched inter-basin and inter-republican water resource management plan.

But the population growth, spurt in industrial urbanisation and improvement in living conditions caused a marked increase in water use. This increase changed the water resource Management Planning for long term demand and encompassed a wider range of subjects than planning of specific projects.

After 1950s during Krushchev period the Management Planning included water related issues, interactions between water sector and other sectors of the economy or the social structure as well as interactions and trade-off between different water related sectors. But the special emphasis was to increase the arable land area of cotton and growth of irrigation system in the region this necessitated modified water resource management plans in the form of legislation, managerial structure and function plan through which large dams and reservoirs were constructed and automated management of water resource use and policy was adopted. With the expansion of urban and industrial area, the over - exploitation of ground water and surface water became an acrimonious problem. Though the ground and surface water management plan, industrial water management, water reuse and water recycling plan and master plans of multipurpose use of water resources were launched. Yet technology and efficiency of water resource use and management was low which created over-stress on Amu-Darya and Syr-Darya river waters. The over-stress resulted in the depletion of Aral Sea water level and gave birth to dramatic and controversial Siberian Water Diversion Scheme. This dream plan of Khruschev period was abandoned during the Gorbachev period

Water resource management in Soviet Central Asia brought prosperity and overall development in the region. But the management was based on over - exploitative approach, non eco-friendly attitude and biased for specific sector both in supply and demand side. More then 90% surface and sub-surface water was used in agriculture sector. Water management and consumption in the region was not representing the manner of water management as the world community followed for the dry land.

The final findings come through the study is that the geographical condition in Soviet Central Asia to such as, topography physical structure, relief, climatic harshness etc. and rapid population growth and spurt in urban industrialization created a symmetrical impetus on water resource management in the region. The supply of water was dominated by river sector followed by lakes and groundwater. The demand of water was dominated by agriculture sector, urban and domestic sector had comparatively very less supply of fresh water resource. The managerial approach of water resources in the region was based on both over-consumption and conservation majors. The initial stage of management was non-exploitative and eco-friendly, but after the post-second World-war period with the implementation of inter-basin and inter-republican water management policy for increasing irrigated land area for cotton cultivation and other crops, the management policy followed the over utilitarian managerial approach. This caused the depletion of Aral Sea water level and ecological problems in the form of salinization of soil, deforestation, decrease in groundwater quality and level etc. in the whole region. Though the conservation and rational management approach such as master plans, water re-cycling plan, automated management plans were adopted, but they were not capable of satisfing the needs and demands of water as well as in reducing the ecological problem. The idea of Siberian water diversion scheme was good to supply the increasing water demand in the region, only on paper. Practically it became a major threat to regional energy balance and heat resources, structure of weather type, temperature and humidity of air, precipitation distribution, local environment and global ecology. Thus the mute dissatisfaction of the people against this Siberian water diversion scheme resulted in its abolition.

In the water resource management there was lack of water resource development plan, rainwater harvesting and surface water conservation majors, vegetation management, chemical treatment, surface binding treatment, groundwater conservation through artificial recharge and control of evaporation from water bodies. But the overall management was good and based on applicable scientific approaches which brought up prosperity in the region in primary, secondary and tertiary sectors as well and laid the basis for continued development of the five newly independent nations of Central Asia.

The solution of problems lay in the scientific management of the scarse water resources, regulated use of river waters, maintenance of Aral sea water level, use of bio-fertilizers and biopesticides, practising appropriate cropping pattern and crop rotation, plantation over wasteland and sand dunes and hills in order to stabilize them. That former Soviet Central Asian republics have became five independent nations, they need to make an integrated plan to reduce water use for agriculture through improvement in irrigation practices, reducing evaportranspiration, reduction of seepage and improving irrigation water. Proper technology can be adopted for the conjunctive use of surface and groundwater. In areas where rainfall is scanty and not sufficient for recharging, ground water use of surface treatment methods for inducing runoff is desirable. An integrated water harvesting - agri system which combines simple shaped, compacted earth catchments with gravity fed compartmented reservoir can be useful. The constraints of soil erosion and water quality need to be kept in mind. Artificial recharge is a promising technique of controlling decline in ground water level. However it is necessary to have precise information as to how much rechargeable water is available, where, when and at what rate. Aryks and canals require desilting in order to maximise the potential or irrigation. In addition, Mathematical modelling of acquifer systems should require to find the temporal and spatial effects or artificial recharge at the piezometric head. Percolation tanks have great potential to recharge groundwater. Case studies should be undertaken to determine the rates of percolation, evaporation, storage capacity below water table, withdrawal rates, soil permeability etc. so that model studies can be attempted to find optimum capacity of percolation tanks. The effectiveness of tanks of recharging groundwater and finding spatial and temporal distribution of recharged water can be established with such a model. Suitable sites are required to be investigated for exploring the possibility of constructing sub-surface dykes in suitable geological formations. These structures are feasible in narrow gently sloping valleys where bed rocks occur at shallow depths and valley fill of 4-8 m. of thick pervious material is available. The catchment should get at least marginal rainfall to recharge the aquifer fully on the upstream side of the structure. Water rates in urban areas should be linked with water availability status. Appropriate water rates which reflect cost and availability of water may prove effective in making people conscious of judicious use of water. There should be a foal-proof mechanism to check water leakages in the water distribution systems in urban areas, with some economic incentives for detecting water leakeges and making judicious use of water.

Development of less water consuming technologies in industrial sector is the need of the hour in the whole of Central Asia. Coolants can replace water in this industrial sector. Reuse of water in industrial sector must be met through waste recycling plants. Research efforts are needed on ways to reduce the cost of various treatment processes and to eliminate bacteria-based hazards. The environmental impact of various water conservation measures need to be studied to avoid possible conflicts in the region.

Proper education, research and use of modern technology such as remote sensing and G.I.S. is necessary to study resource endowment and spreading ecological awareness among the people, sustainable water resource management should taking into consideration and long term productivity over short-term benefits should be encouraged in the region.

There was sustainability in the water resource management in the region during the Soviet period. But now the independent five nations of Central Asia, need to coordinate their efforts by evolving an agreed framework for water sharing between these Republics. This becomes all the more necessary because Kyrgyzstan and Tajikistan, the upstream countries supplying much needed water to Uzbekistan and Kazekhstan are dependent for their gas and oil needs on the latter two Republics. Given the high potential of conflict on the issue of water sharing, this issue demands urgent attention.

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