CRWR Online Report 98 # 3

Aral Sea Water Rights

by

Sandra Akmansoy, M.S.

Graduate Research Assistant

and

Daene C McKinney, PhD.

Principal Investigator

December 1997

CENTER FOR RESEARCH IN WATER RESOURCES

Bureau of Engineering Research • The University of Texas at Austin
J.J. Pickle Research Campus • Austin, TX 78712-4497

This document is available online via World Wide Web at
http://www.ce.utexas.edu/centers/crwr/reports/online.html

Acknowledgements

I would like to thank Dr. Daene McKinney and Dr. David Maidment for their advice, support and guidance.

I would also like to thank Seann Reed, Kwabena Asante and Dr. Francisco Olivera for their patience and help with my never ending questions and problems.

December 3, 1997

Abstract

Aral Sea Water Rights

by

Sandra Akmansoy, M.S.E

The University of Texas at Austin, 1997

Supervisor: Daene C. McKinney

The Aral Sea, whose basin includes the countries of Kazakstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, occupies an area of 66,000 km^2 and a volume of 1,060 km^3 in 1960. Since 1960, the amount of irrigated land has increased by 100%, and the population in the basin has increased by140%. The flow from the Amu Darya and Syr Darya, the rivers which supply 90% of the Aral Sea's water resources, was diverted for irrigation and to sustain the booming population since the 1950s. As a result, the Aral Sea has lost 50% of its surface area and 66% of it volume, and has become an environmental disaster area.

Before the fall of the Union Soviet Socialist Republic, the water resources in Central Asia were shared between the Republics. Since the fall of the USSR,

the topic of water rights has emerged. The downstream nations of Turkmenistan, Kazakstan, and Uzbekistan are dependent on the Aral Sea basin for irrigation especially during the hot summer months. The upstream nations of Kyrgyzstan and Tajikistan are dependent on the Aral Sea basin for hydroelectric power especially during the cold winter months. As these Central Asian countries try to negotiate treaties and regulations on water use, the Helsinki Rules have been cited and quoted as being the standard in determining the rights of the upstream countries to release or hold water storage.

The Helsinki Convention, redrafted in May 1997 and adopted by the International Law Commission list 11 factors, to be weighed equally, in determining water rights: (1) the extent of drainage area, (2) the contribution of water, (3) the climate, (4) past and present utilization of the waters, (5) economic and social needs, (6) population dependent on the waters, (7) comparative costs of social and economic alternatives, (8) availability of other resources, (9) the optimization of the waters, (10) practicability of compensation , and (11) the degree to which a nation may be satisfied without causing harm to another nation. These factors were analyzed in respect of the Aral Sea basin to determine the water rights of each country.

The hydrology of the Aral Sea basin is analyzed using Geographic Information Systems (GIS). The watershed and streams of the basin are delineated to compute the extent of watershed within each country: the downstream countries, Uzbekistan, Kazakstan, and Turkmenistan have the greatest shares of the Aral Sea basin. GIS is also used to compute the evaporation

and water surplus of the area. A snowmelt component based on precipitation as rain and snow is incorporated to the program because of the high altitudes (greater than 8,000 meters) and low temperatures (average below $0^{o}C$) in part of the basin. The results showed that the upstream countries, Tajikistan and Kyrgyzstan, produce the largest amount of water surplus in the Aral Sea basin.

The economy of Central Asia has suffered tremendously since the fall of the Soviet Union. There are high rates of inflation, poverty, unemployment, credit shortages, and declines in the gross domestic product (GDP). Furthermore, the Aral Sea crisis, with the pollution of the rivers, and the salt windstorms, has caused cancer, anemia, miscarriages, and respiratory and circulatory problems, to increase substantially, especially in the regions nearest to the Aral Sea.

The conclusion of this thesis is that the non-hydrologic factors of The Helsinki Convention are hard to answer and apply to circumstances. The economic or social dependence of one country is hard to rate or classify above another country's. GDP, social, employment, and health statistics cannot be the only basis for determining who is more "dependent. However, based on the hydrologic study, all five countries have equal rights to the Aral Sea waters.

Table of Contents

List of Tables x

List of Figures xi

Chapter 1: Introduction 1

Background 1

Study Area 4

Research Approach 7

Chapter 2: The Hydrology and Climate of the Aral Sea Basin Using Geographic Information Systems 13

Introduction 13

Spatial hydrology of the aral Sea 13

Soil Water Balance 30

Chapter 3: Social and Economic Study 52

Kazakstan 53

Uzbekistan 68

Turkmenistan 83

Tajikistan 97

Kyrgyzstan 112

Chapter Summary 128

Chapter 4: Sharing the Aral Sea Basin Waters 134

Introduction 134

Effects To The Aral Sea Environment 134

Past and present Utilization 138

Existing Treaties 145

Analysis of the Helsinki Rules 151

Chapter 5: Conclusions 154

Geographic Information Systems 154

Helsinki Rules....155

Appendices 159

Appendix A:The Helsinki Rules on the Uses of the Waters of International Rivers (Source: MFA)....159

Appendix B: Convention on the Law of the Non-navigational Uses of International Watercourses Adopted by the UN General Assembly May 1997....165

Appendix C: Projection FIles 181

Appendix D: Delineation AML 183

Appendix E: Inland Catchment AML....185

Appendix F: Fortran Program for Snow Melt 187

Bibliography 192

Vita 196

List of Tables

Table 2. 1: Comparison of the Computed and Documented Areas of the Aral Sea Basin. 29
Table 2.2: Annual Water Surplus for Different Snow Temperatures. 47
Table 3. 1: Ethnic Groups in Kazakstan 55
Table 3.2: Ethnic Groups in Uzbekistan 70
Table 3.3: Ethnic Groups in Turkmenistan 84
Table 3.4: Ethnic Groups in Tajikistan 99
Table 3. 5: Ethnic Groups in Kyrgyzstan. 113
Table 4.1: Inflow to the Aral Sea basin in 1994 (km^3/yr). 140
Table 4.2: Projected Inflow to the Aral Sea Basin in 2010 (km^3/yr). 140
Table 4.3: Measures (1994) and estimated (2010) uses of the Aral Sea basin waters (km^3/yr). 141
Table 4.4: Uses of water in the Aral Sea basin, km^3/yr (World Bank, 1996). 142
Table 4.5: Documented irrigation (1994) and projected (2010) water use (World Bank, 1996). 145
Table 4.6: Helsinki Rules ranking of each country (1= best, 5= worst). 151

List of Figures

Figure 1.1: Map of the Aral Sea Region.....5
Figure 1.2: Topography of the Aral Sea Region.....6
Figure 2.1: Topographic map of the Aral Sea basin from the USGS 30" DEM, GTOPO30.....15
Figure 2.2: Original stream delineation for the Aral Sea basin. 17
Figure 2.3: Streams of the Aral Sea basin from the Digital Chart of the World. ..20
Figure 2. 4: European Union TACIS Program coverage of digitized streams of the Aral Sea basin. 22
Figure 2.5: Aral Sea basin streams to be burned in. 23
Figure 2.6: Stream and watershed delineation for the Aral Sea basin. 26
Figure 2.7: Comparison of the GIS delineated and EU TACIS Program streams for the Aral Sea basin. 27
Figure 2.8: Percent of Aral Sea basin in each country. 28
Figure 2.9: Soil water holding capacity of the Aral Sea basin (mm). 31
Figure 2.10: Average annual temperatures in the Aral Sea basin (^{o}C). 33
Figure 2.11: Mean monthly net radiation (W/m^2). 34
Figure 2.12: Mean annual precipitation in the Aral Sea basin (mm).....35
Figure 2.13: Annual evaporation in the Aral Sea basin (mm/yr). 42
Figure 2.14: Annual water surplus in the Aral Sea basin without snowmelt (mm/yr). 44
Figure 2.15: Annual water surplus in the Aral Sea basin with snowmelt at 2^{o}C (mm/yr). 45
Figure 2.16: Annual water surplus in the Aral Sea basin with snowmelt at 0^{o}C (mm/yr). 46
Figure 2.17: Precipitation versus water surplus for no snowmelt and snowmelt at 2^{o}C and 0^{o}C.....49
Figure 2.18: Pie chart for percent of annual water surplus for each Aral Sea country (snow at 2^{o}C and 0^{o}C). 51
Figure 3. 1: Location of Kazakstan.....54
Figure 3.2: Location of Uzbekistan. 69
Figure 3.3: Location of Turkmenistan. 84
Figure 3.4: Location of Tajikistan. 98
Figure 3.5: Location of Kyrgyzstan. 113
Figure 3.6: Minerals in the Aral Sea basin. 129
Figure 3.7: Population density in Central Asia (1 person/km^2). 130
Figure 4.1: Landuse in the Aral Sea basin (ArcAtlas, 1997). 136
Figure 4.2: Present share of agricultural water in the Aral Sea basin.....144
Figure 4.3: Water surplus, allocation, and consumption in the Aral Sea basin. ..146
Figure 4.4: Exchange of resources in the Aral Sea basin. 150

Chapter 1: Introduction

BACKGROUND

The Central Asian Republics of Uzbekistan, Kazakstan, Kyrgyzstan, Tajikistan, and Turkmenistan depend on the rivers which feed the Aral Sea for hydroelectric power and irrigation. Due to large-scale diversion of the Amu Darya and Syr Darya rivers since the 1950s to irrigate Central Asian cotton fields, the Aral Sea has lost half of its surface area and two thirds of its volume. Water quality continues to decrease as the lake level drops, and windstorms on the former sea bottom carry salty grit to area residents, who suffer from respiratory ailments and throat cancer (World Bank, 1996).

Since 1960, the population of the Central Asian republics has increased from about 13.6 million to 32.8 million, or by 140 percent. In that same time, agricultural production per year of key crops such as cotton rose by 100 percent to 7.7 million metric tons per year, with a corresponding increase in the amount of land under irrigation. Meanwhile, output in industrial enterprises involving substantial abstraction or diversion of water climbed steeply to very high levels: steel production rose by 200 percent, cement production rose by 170 percent, and electricity production rose by a factor of twelve (Gleason, 1991).

The growth in population, industry and agriculture have strained Central Asia's limited water resources. There is very little precipitation to support the great demand for water except from rivers which originate in the high mountain ranges in the eastern parts of Central Asia. Before the fall of the Soviet Union in

1991, the five Central Asian countries were considered as states where natural and economic resources, and costs were shared equally. Times have changed; the upstream countries of Tajikistan and Kyrgyzstan utilize the water in the rivers mostly to produce hydroelectric power, especially during the cold winter months. Meanwhile, the downstream countries of Kazakstan, Turkmenistan and Uzbekistan utilize the waters for agricultural purposes in the summertime. This has caused great debate over who has the right to the water in the Aral Sea basin. Do the upstream countries have the right to detain the water from downstream countries, to release waters at times which may not be optimal for the downstream countries, or do downstream countries have the priority to use those waters due to their pattern of historical use? These questions will be explored below.

Condition of the Aral Sea

The increased diversion of water from the Aral Sea basin rivers has allowed the development of massive agricultural complex in Central Asia, while at the same time degrading the ecosystem and environment of the region. The flow of the Syr Darya between 1974 and 1986 never reached the Aral Sea due to diversion for irrigation purposes. In 1982, 1983, 1985, 1986 and 1989, there was absolutely no inflow from the Amu Darya into the Aral Sea (Bortnik, 1992). This caused the Aral Sea level to decrease by 89 to 109 centimeters per year between 1974 and 1989. Furthermore, the decrease in sea level has caused the Aral Sea to separate into 2 water bodies the Small and Large Aral Seas (Maloye More and Bol'-shoye More) each being nourished by separate rivers, the Syr Darya, and Amu Darya, respectively.

The Aral Sea has attained a salinity of 30 grams per liter, which is comparable to the North Sea (Klotzli, 1994). An increase in salinity is "determined for the most part by an increase in the concentration of salts upon a decrease in water volume" (Bortnik, 1992). The Aral Sea's increasing salinity has destroyed the ecosystem causing irreversible changes. Rising salinity levels have eliminated the commercially-valuable fish in the sea, and have caused salt windstorms detrimental to the population's health.

Aral Sea Disaster Zone

The Autonomous Republic of Karakalpakstan, suffering more than any other region in Central Asia from the cumulative effects of the Aral Sea crisis, is located in Uzbekistan at the delta of the Amu Darya. Due to decades of irrigation that paid more attention to centrally-planned quotas than the state of the environment, nearly the whole of Karakalpakstan is either salinized or waterlogged (OneWorld, 1997). Key factors harming the environment are discharge of highly mineralized, pesticide-rich return flows into rivers, use of unlined irrigation canals leading to waste and seepage of salts into groundwater, waterlogged fields leading to salty groundwater and salt runoff, and no drainage network to remove unwanted water and chemicals from the fields (FAO, 1997). By the end of the 1980s, more than three billion cubic meters of drainage water contaminated with agricultural chemicals from Uzbek and Turkmen fields, together with untreated industrial and municipal wastes, were being dumped in the Amu Darya River each year. Much of it ended up in Karakalpakstan, where it

poisoned aquatic ecosystems and contaminated drinking water supplies (OneWorld, 1997).

The degraded environment has caused many problems to the economy and the population of Karakalpakstan. Most fisherman have lost their jobs due to the decreasing shoreline and increasing water pollution. There has been an increase of total mortality by 15 times, of cardiac and vascular diseases by 1.6 times, of tuberculosis by 6 times, of gallstone disease by 5 times, and of throat cancer by 7 to 10 times (DEV, 1997). The people of Karakalpakstan also suffer from rising rates of thyroid and kidney disease. Over the period 1981 to 1987, it is estimated that liver cancers soared an incredible 200 percent, throat cancers were up 25 percent and infant mortality climbed 20 percent (FAO, 1997).

Sadly, there are little funds being used to save Karakalpakstan. Most of the watershed states are now busy trying to squeeze as much water out of the Amu Darya and Syr Darya Rivers as possible. Ironically, the extra water, they argue, is needed to expand irrigated agriculture (mostly cotton for export), which each of the region's governments sees as a way to improve their faltering economies. Environmental concerns have been shoved aside by short-term economic considerations (OneWorld, 1997).

STUDY AREA

The study area for this thesis is the Aral Sea Basin, which is surrounded by the Kyrgyz Republic, Tajikistan, Uzbekistan, Turkmenistan, and Kazakstan (Figure 1.1). The Aral Sea is supplied by two main rivers, the Amu Darya and the Syr Darya. The area of these countries is approximately 3.99 million square

kilometers while the Aral Sea Basin has an area of 1.512 million square kilometers.

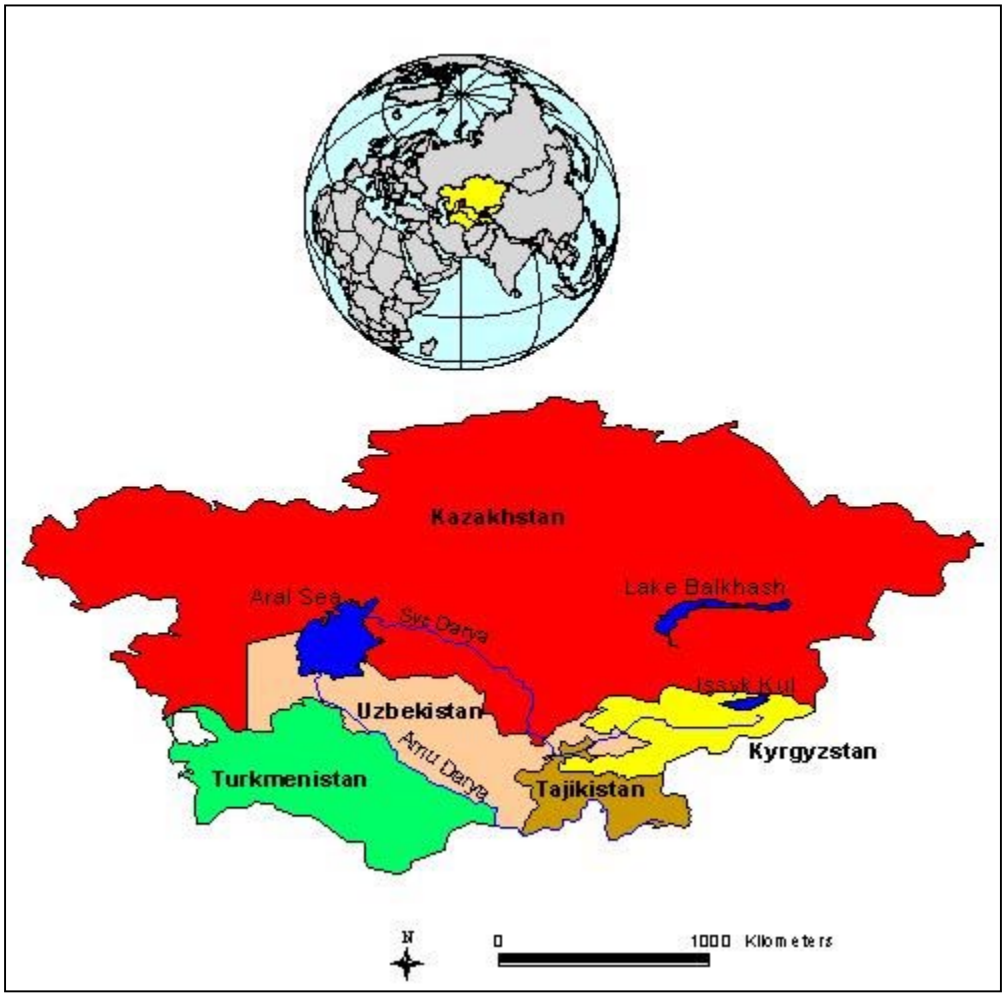

Figure 1.1: Map of the Aral Sea Region

Topographically, the Aral Sea Basin is complicated (Figure 1.2). It ranges from the vast Turanian Plains in the West to the tremendous mountain ranges of the Pamirs and Tien Shan joining in the south and southeast, with peaks reaching

6000 to 8000 meters and higher. The plains make up about 80% of the total area of the basin, while mountains occupy about 20% of the area (UNEP, 1991).

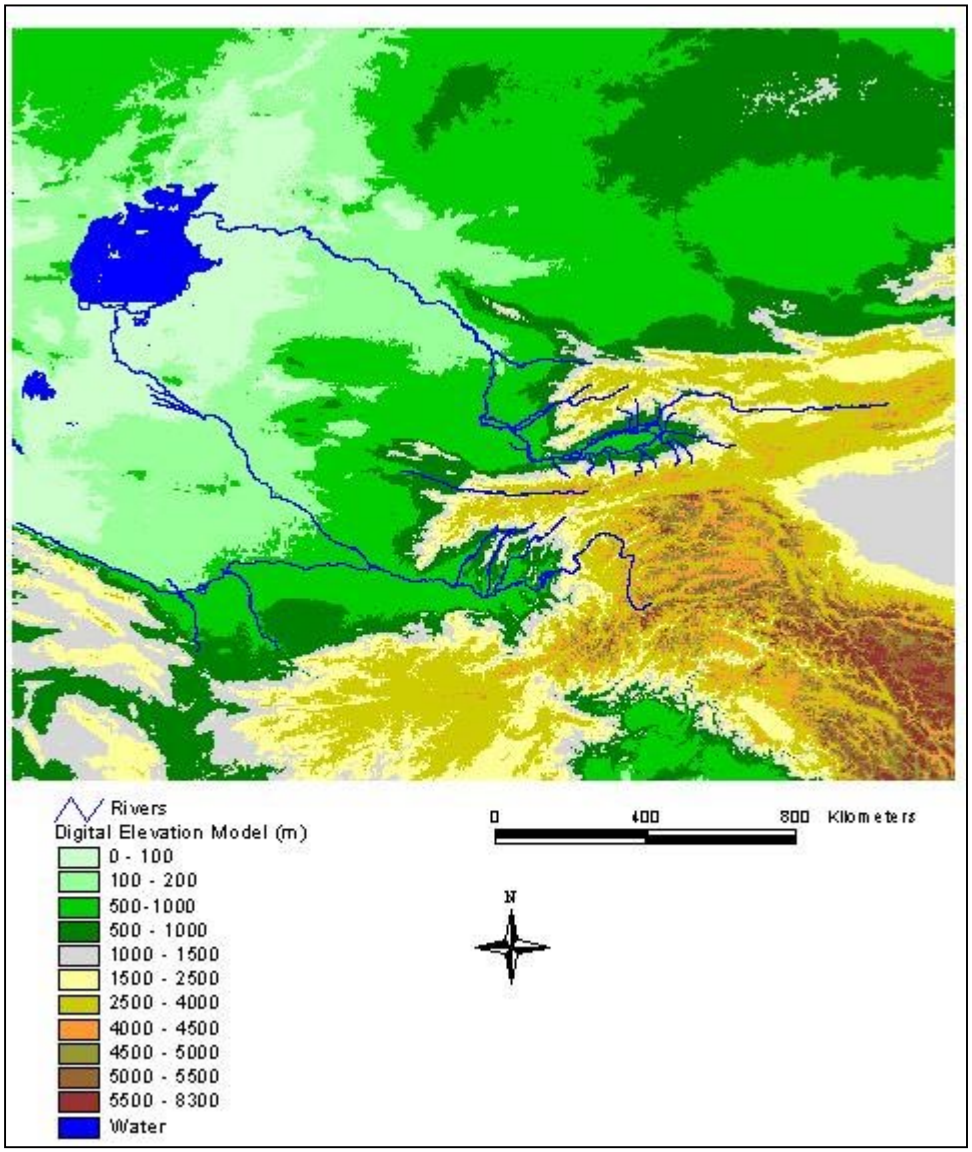

Figure 1.2: Topography of the Aral Sea Region

The climate in the northern part of the basin is continental. In the southern parts, it is subtropical. The high mountain areas, with precipitation from 800 to 1600 millimeters, are humid and account for the moisture surplus in the region (Klotzli, 1994). Water from the two rivers, Amu Darya and Syr Darya, irrigate roughly 75% by area of production of Central Asia's agriculture. Water resources are mainly surface waters that are concentrated in the huge mountains forming the catchment zone of the water cycle in the region. Melting water from extended permanent snow fields and glaciers feed the powerful rivers of Amu Darya and Syr Darya mostly during spring thaw. The Tien Shan and Pamir ridges have together more than 18,000 square kilometers of ice cover.

The Amu Darya with 2,540 km from the confluence of the Pyandzh and Vakhsh to the Aral is the largest river and most important drainage basin in Central Asia, whereas the Syr Darya stretches some 2200 km in length from the Naryn River in Kyrgyzstan through the Fergana Valley, the Hunger Steppe and the Kysyl Kum desert. The two main rivers of the Aral Sea basin account for about 90% of the annual river flow. The rivers have their maximum discharge when they leave the mountains, but naturally lose half of their flow through filtration and evaporation while crossing the desert before reaching the Aral Sea (Klotzli, 1994).

RESEARCH APPROACH

International Legal Precedents

Domestic laws in any sovereign state are usually written laws based on tradition, common law, and administrative rules which citizens are obligated to

follow. In the international arena, laws are consensual and a country usually consents to international laws because the long-term benefits outweigh the long-term costs. International laws can be proven or established by the existence of treaties or conventions to which a large number of nations have agreed to be bound. An international law can also be shown to exist if it has been formally adopted by the United Nations General Assembly. Adoption by any other UN agency may provide support for the assertion that a principle is in fact an international law, but such an adoption cannot stand alone. It can provide significant proof only when a substantial majority including major world powers have adopted the resolution (Draper, 1997).

There are not many treaties or laws that dictate the proper use of international waters. The United Nations provides the mechanism to identify solutions to disputes or problems, and to deal with virtually any matter of concern to humanity. The United Nations has only one convention on international waters, which addresses the problem of equitable sharing, The Helsinki Rules of the International Law Association on the Uses of the Waters of International Waters (1966). The "Helsinki Rules" were adopted by the International Law Association (ILA) in 1966 and the United Nations International Law Commission (UN-ILC) in 1994 (MFA, 1996). The Commission is composed of 34 members who serve in their individual capacity as international law experts and represent the principal legal systems of the world. The Commission, which was established on 21 November 1947 by the UN General Assembly to initiate studies and make recommendations for the purpose of encouraging the progressive development of

international law and its codification, has been at the center of standard setting in its preparation of drafts that have served as the basis for the adoption of legal rules to regulate relations among States.

Chapter 2, Article V of the Helsinki Rules states the following (Appendix A):

1. Each basin State is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an international drainage basin. This equitable sharing is to be determined in the light of all the relevant factors in each particular case.
2. Relevant factors which are to be considered include, but are not limited to:
    - The geography of the basin, including the extent of the drainage area in the territory of each basin State;
    - The hydrology of the basin, including the contribution of water by each basin State;
    - The climate affecting the basin;
    - The past utilization of the waters of the basin, including existing utilization;
    - The economic and social needs of each basin State;
    - The population dependent on the waters of the basin in each basin State;

- The comparative costs of alternative means of satisfying the economic and social needs of each basin State;
- The availability of other resources;
- The avoidance of unnecessary waste in the utilization of waters of the basin;
- The practicability of compensation to one or more of the co-basin States as a means of adjusting conflicts among uses; and
- The degree to which the needs of a basin State may be satisfied, without causing substantial injury to a co-basin State.

3. The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable share, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

This law was revised in May 1997 and called "The Convention on the Law of the Non-navigational Uses of International Watercourse" (Appendix B). However most of the relevant factors related to equitable and reasonable utilization of water remained the same.

The reliability and obligation of using the Helsinki Rules to determine water rights must be established before applying the Helsinki Rules to water rights in Central Asia. Draper (1997) discusses the four duties under international law of sharing transboundary water resources: the duty to cooperate and to negotiate in good faith, the duty to prevent unreasonable harm, the duty of

equitable utilization, and the duty to exchange data and information. He argues that there does not appear to be any sufficient proof that the principle of equitable utilization is an international legal norm to which all states involved in a water sharing agreement must adhere. For this study area, this argument can easily be discredited. Although the UN General Assembly has not formerly adopted the Helsinki Rules, the UN International Law Commission, established by the General Assembly, has adopted the Helsinki Rules. Also, all five of the Central Asian countries are members of the UN and have repeatedly quoted and supported the Helsinki Rules as a basis for water rights in documents, meetings, and treaties. This also discredits Draper's questions about whether countries are obligated to follow "equitable and reasonable" principles as a matter of international law or whether these obligations must be explicitly agreed upon.

Draper (1997) also argues that the fulfillment of the duty to prevent unreasonable harm and the duty of equitable utilization can be challenged due to the vagueness of terms; does "reasonable and equitable utilization" mean beneficial use, what is the difference between reasonable harm and unreasonable harm, and how can a country quantify the difference between using waters for agricultural purposes and environmental protection and which is a priority?

Objectives and Methodology

The original Helsinki Rules, and their revised version, have similar criteria to determine water rights. The most important characteristics in determining equitable use of international waters are social-economic factors, the hydrology

and environment of the basin, and the satisfaction of one country without damaging another country or the environment.

The methodology for this study is therefore partitioned according to the major criteria for water rights. First, the hydrology and climate study of the region is analyzed using Geographic Information Systems (GIS). GIS is used to delineate the watersheds and streams which feed the Aral Sea. These data are used to determine each country' share of the watersheds. The water surplus from rain and snow is also determined using GIS, and each country's contribution to the water surplus is also calculated.

Second, the social and economic needs of each country, their available resources, and their dependence on the Aral Sea waters are discussed. The Helsinki Rules specify that the social and economic status of a country is equally important as its hydrology in determining water rights. Chapter 3 also includes the effects of the crisis of the Aral Sea on each country's economy and population.

Third, the past utilization of the waters, the conservation, the protection, and the development of the Aral Sea basin are discussed in Chapter 4. The treaties which are currently being practiced between the countries and their justification under the Helsinki Rules are also discussed. Finally, Chapter 6 examines the data from the previous chapters, and discusses the conclusions, further work, and limitations.

Chapter 2: The Hydrology and Climate of the Aral Sea Basin Using Geographic Information Systems

INTRODUCTION

A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on Earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

This chapter explains the methodology of performing a spatial hydrologic study of the Aral Sea basin. The topics covered include inland catchments, watershed and stream delineation, soil water balance and snowmelt runoff.

SPATIAL HYDROLOGY OF THE ARAL SEA

Stream and Watershed Delineation

The shape of a surface determines how water will flow across it. The hydrologic analysis tools of GIS provide a method to describe the physical characteristics of a surface. Using a digital elevation model as input, it is possible to delineate a drainage system and then to quantify the characteristics of that system. Watersheds can be delineated from a Digital Elevation Model (DEM) using the output from the flowdirection function of ArcInfo. The area upon which

water falls, and the network through which it travels to an outlet is referred to as a drainage system.

Digital Elevation Model

A topographic map, which is a ramp-shaded presentation of the DEM of the Aral Sea area, is presented in an Albers projection in Figure 2.1 (Appendix C). GTOPO30, a DEM distributed by the USGS (United States Geological Survey), is a topographic surface arranged in a data file as a set of regularly-spaced *x,y,z* locations where *z* represents elevation (ESRI, 1997). The DEM is the starting point of any GIS based hydrologic modeling. The DEM used for this analysis consists of 6.4 million 30 by 30 minute cells, which are approximately equal to 1 kilometer between measured locations.

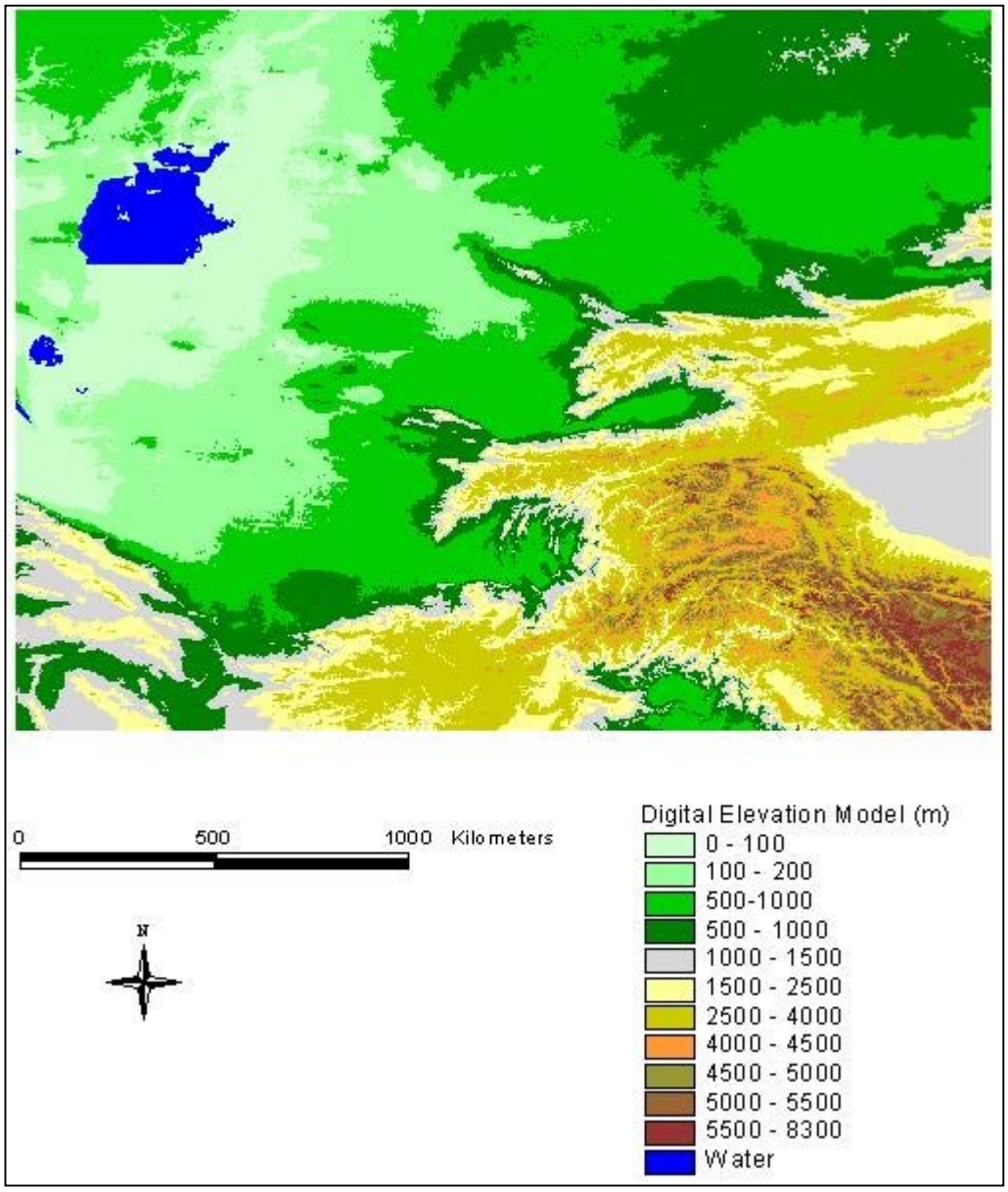

Figure 2.1: Topographic map of the Aral Sea basin from the USGS 30" DEM, GTOPO30.

The methodology for delineating streams and watersheds from a raster digital elevation model (DEM) is based on the *eight direction pour-point algorithm*. This algorithm identifies the grid cell, out of the eight surrounding cells, towards which water will flow if driven by gravity (Olivera, 1997). This methodology consists of:

- Filling the sinks of the DEM, i.e., increasing the elevation of the points that are fictitious depressions known as pits.
- Determining the flow direction, i.e., identifying the cell towards which water will flow.
- Calculating the flow accumulation, i.e., evaluating the drainage area in units of grid cells.
- Identifying the stream cells, i.e., identifying those cells with a flow accumulation value greater than a certain user-defined threshold value.
- Labeling the links, i.e., assigning a label (number) to each reach of the stream network.
- Delineating the watershed for each link, i.e., determining the incremental drainage area associated with each link.

A delineation AML (Arc Macro Language Program) can be run "in the background" in ArcInfo to determine the stream and watershed delineations from the DEM. This is convenient for large areas which usually require several hours to be processed. Commands for this AML can be found in Appendix D. It should be noted that watershed and stream delineation can also now be done in the Spatial Analyst extension of ArcView 3.0.

Inland Catchment

When the stream and network delineations for the Aral Sea Basin were first made, shown in Figure 2.2, all the streams seemed to be flowing towards the Caspian Sea rather than the Aral Sea. Therefore, an inland catchment AML, which addresses the problem of inland catchments with Digital Elevation Models, during watershed delineation was used (Appendix E). Inland catchments constitute closed hydrologic systems that do not drain to the ocean, as do most watersheds. In inland catchments, water drains towards an inland pour point located within the basin, and not towards the basin border.

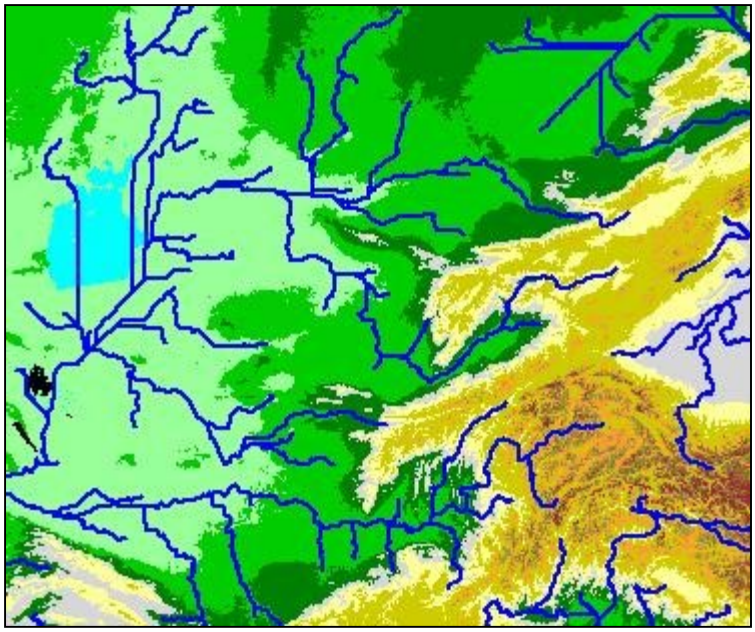

Figure 2.2: Original stream delineation for the Aral Sea basin.

To guarantee that delineated streams match observed streams and flow gauging stations, the DEM was corrected by increasing the elevation of all cells except for the ones that coincide with the observed streams. This process is equivalent to digging trenches wherever a stream has been observed. This algorithm does not force the water to flow to the streams, but instead forces the flow to remain in the streams once it gets there.

The difficulty in delineating inland catchments is that the standard delineation procedure requires a depressionless DEM. "Satisfying this requirement guarantees that the water is able to flow along the landscape without being trapped in depressions. The existence of DEM depressions is explained by pits (DEM errors that might be small but critical for hydrologic modeling), and by inland catchments (in which the lowest cell constitutes a pour point)" (Olivera, 1997). Therefore, before delineating the streams, the DEM has to be corrected in the following ways: (1) filling the pits (using the FILL function of Arc/Info-Grid), (2) subtracting the original DEM from the filled DEM, and (3) assigning a NODATA value to the lowest cell of the inland catchment (pour points). The Aral Sea was identified manually as the inland catchment.

Digital Chart of the World

The next step was to use the Digital Chart of the World (DCW) (ESRI, 1996) to get the streams of the region. The gray lines in Figure 2.3 indicate the thousands of streams which were taken from the DCW. The blue lines show the streams that were selected from the DCW to be burned in the DEM. This

burning-in process consists of raising the elevation of all the cells but those that coincide with the digitized streams. By doing this, water is forced to remain in the streams once it gets there; however, it is not forced to flow towards them. Extensive experience at the CRWR has shown that the streams delineated using this improved methodology represent much better the real stream network than the streams derived form the DEM alone. This process consists of:

- Converting the line coverage of digitized streams into a grid (with value 1 in the stream cells and NODATA elsewhere).
- Making sure that this grid presents continuous streams (no gaps), does not involve short circuits, and extends out of the study area.
- Adding a constant value to the DEM, 50000 in this case.
- Merging the two grids together, keeping the stream grid on top of the modified elevation grid, to obtain the burned-DEM.

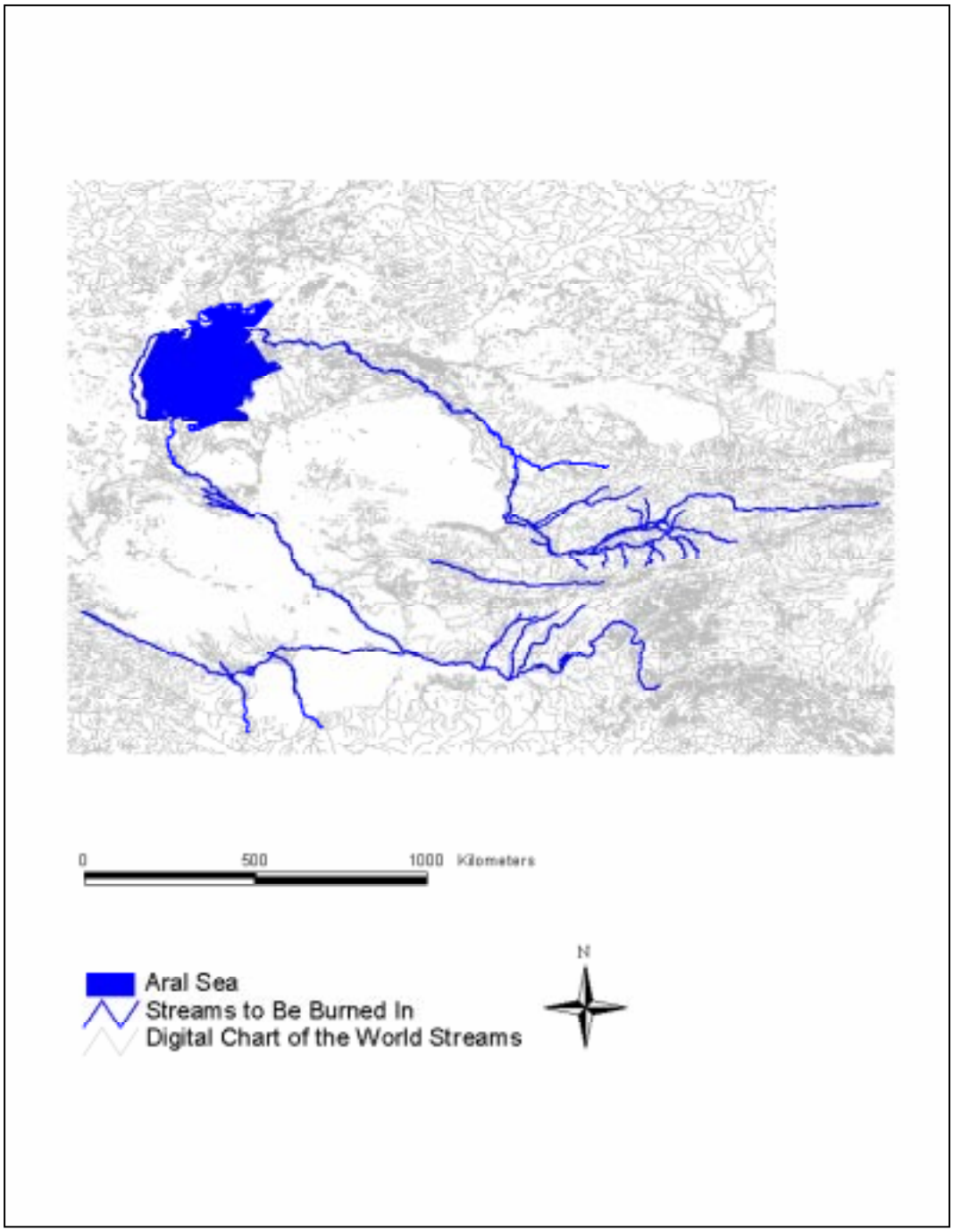

Figure 2.3: Streams of the Aral Sea basin from the Digital Chart of the World.

Selecting arcs one by one to create this coverage took a very long time. The task was made easier by looking at the streams surveyed by the European Union TACIS Program coverage (Gunn, 1996). The EU TACIS Program coverage, shown in Figure 2.4, was originally in a Transverse Mercator projection, and therefore had to be converted from Transverse to Albers (Appendix C). The final coverage of streams to be burned is showed in Figure 2.5.

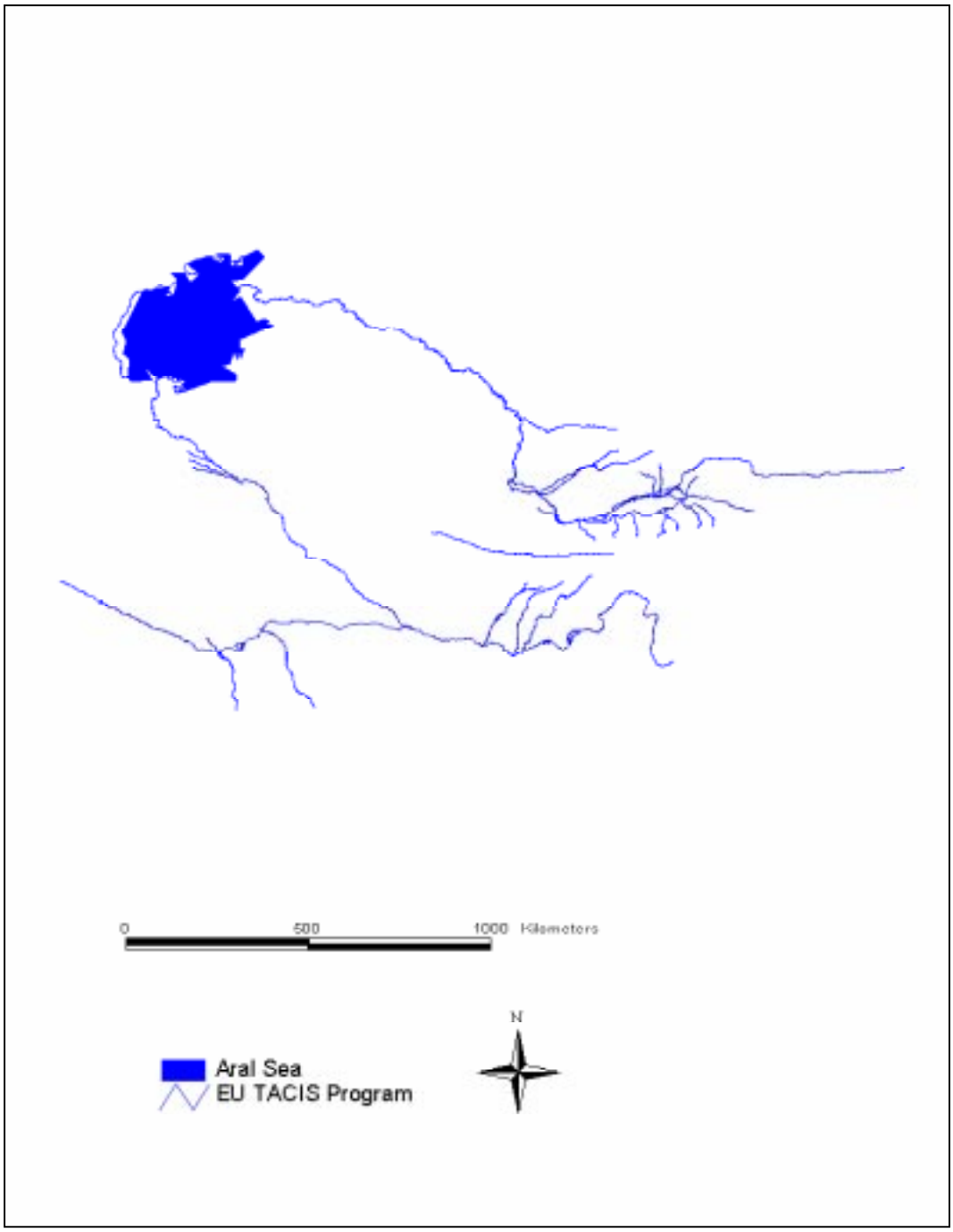

Figure 2. 4: European Union TACIS Program coverage of digitized streams of the Aral Sea basin.

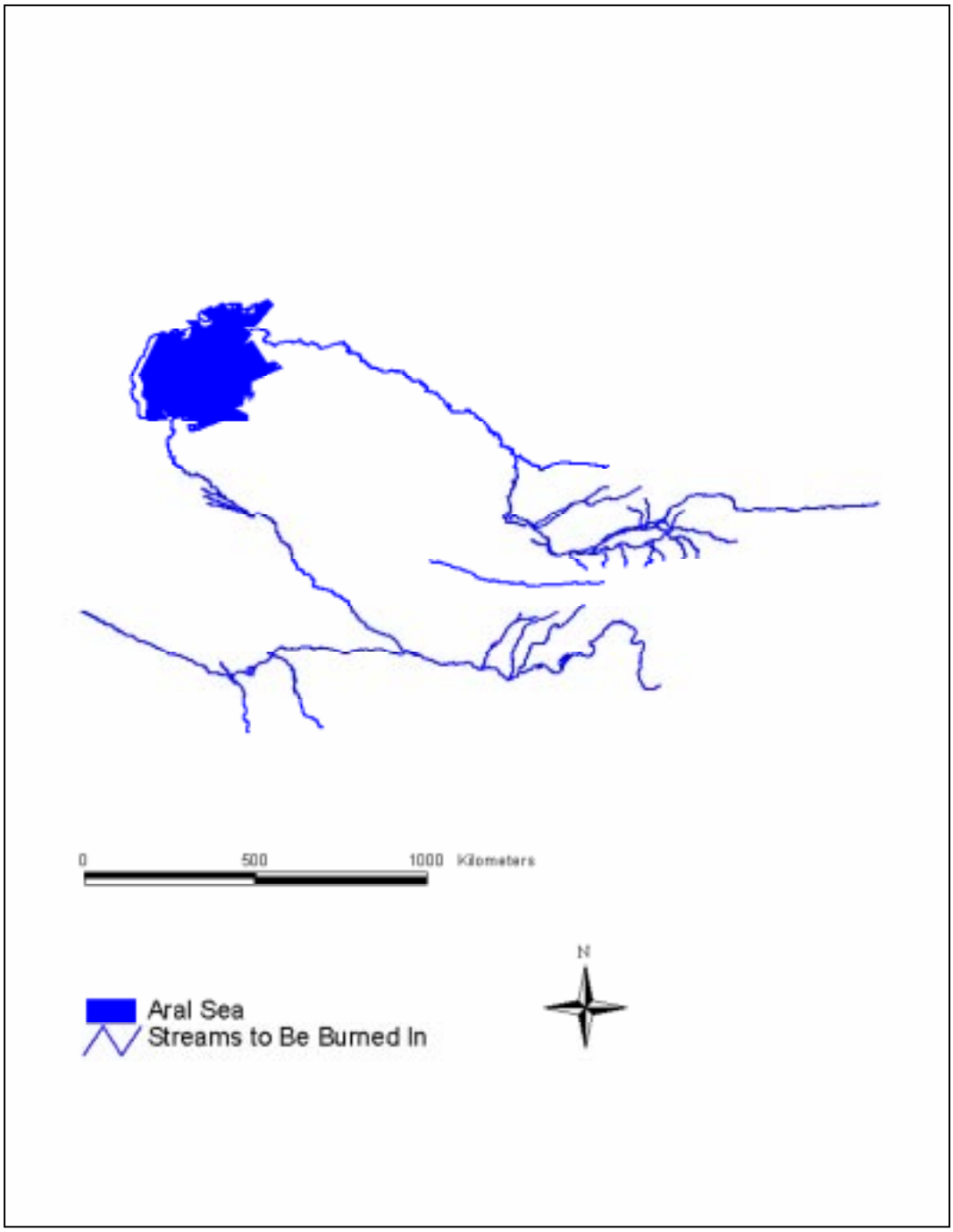

Figure 2.5: Aral Sea basin streams to be burned in.

Watershed and Stream Delineation of Burned DEM

The DEM was "burned in" by setting the stream cells to zeros and effectively burning in the streams. ArcInfo LINEGRID was also used to rasterize the digitized stream networks. DEM's usually contain sinks; A sink is a cell with undefined drainage direction; all cells around it are higher. For a hydrologic DEM to be created, all the sinks in the burned DEM must be filled in. By using the Fill command in ArcInfo, all sinks which are lower than their lowest adjacent neighbor will be filled to the height of their pour point. The pour point is the boundary cell with the lowest elevation for the contributing area of a sink.

Once the sinks have been filled, the flowdirection grid can be determined. The ArcInfo Flowdirection function assigns to each cell a number corresponding to which of the 8 neighbouring cell which lies on the path of steepest descent. The cells flow to their nearest neighbour along 1 of 8 compass directions labeled as East = 1, SE = 2, S = 4, SW=8, W=16, NW=32, N=64, NE=128. The direction of flow is determined by finding the direction of steepest descent from each cell. The flowaccumulation is greater in the Amu Darya than in the Syr Darya, because the area is greater in the Amu Darya. The area of the Amu Darya basin is 847,000 square kilometers while the area of the Syr Darya is 370,000 square kilometers; the entire watershed is equal to 1.217 million square kilometers.

Next a grid of the streams was created. Different results are obtained depending on the threshold value of flow accumulation used. The threshold is the minimum area necessary to create a stream; in this case 3000 cells (3000 square

kilometers) were used. A higher threshold produces fewer streams than a lower threshold. Then, the watershed delineation was created by locating the outlet cell at the bottom end of each watershed. Figure 2.6 shows the delineated streams and watersheds in an Albers Projection (Appendix C). Using a threshold of 3000 gave the best coverage in comparison to the EU TACIS Programme streams, shown in Figure 2.7.

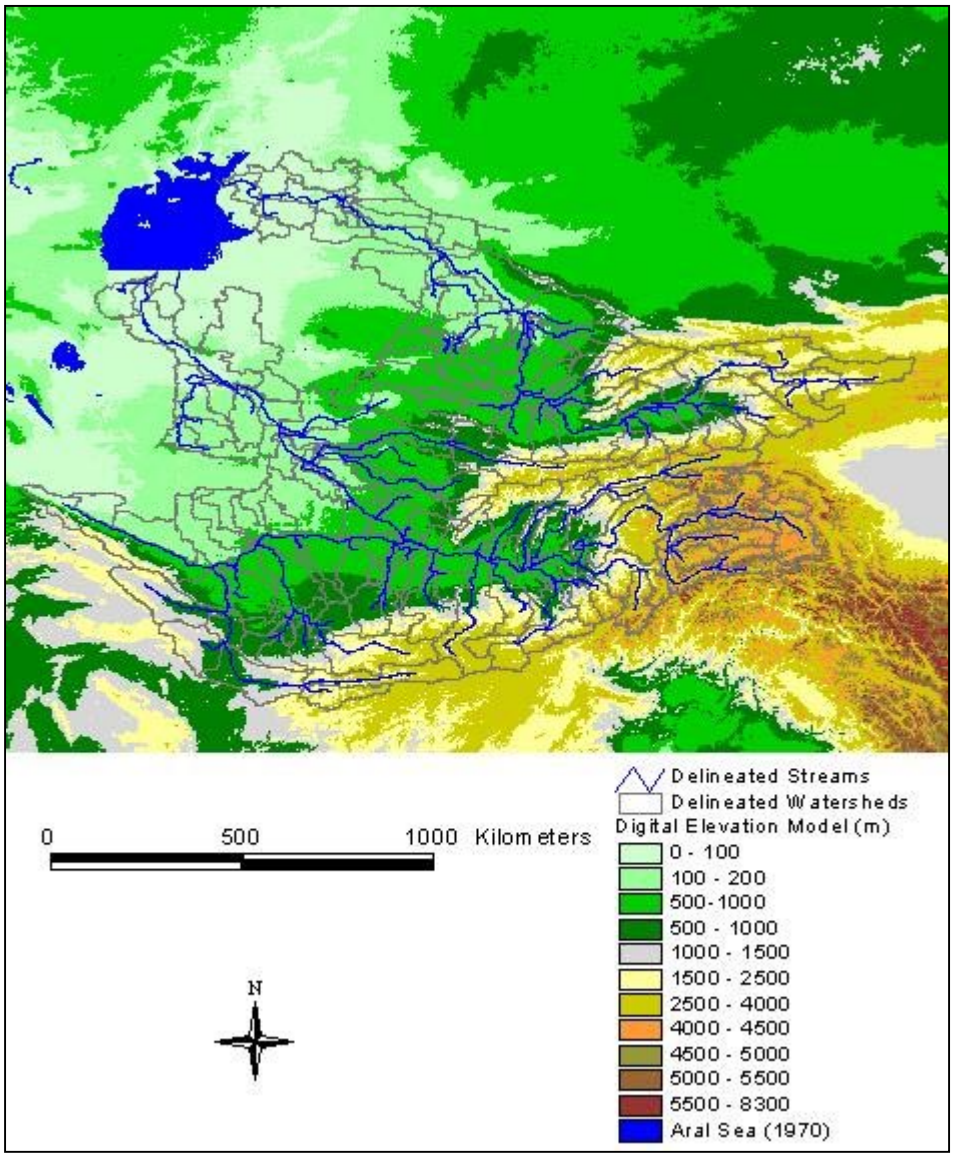

Figure 2.6: Stream and watershed delineation for the Aral Sea basin.

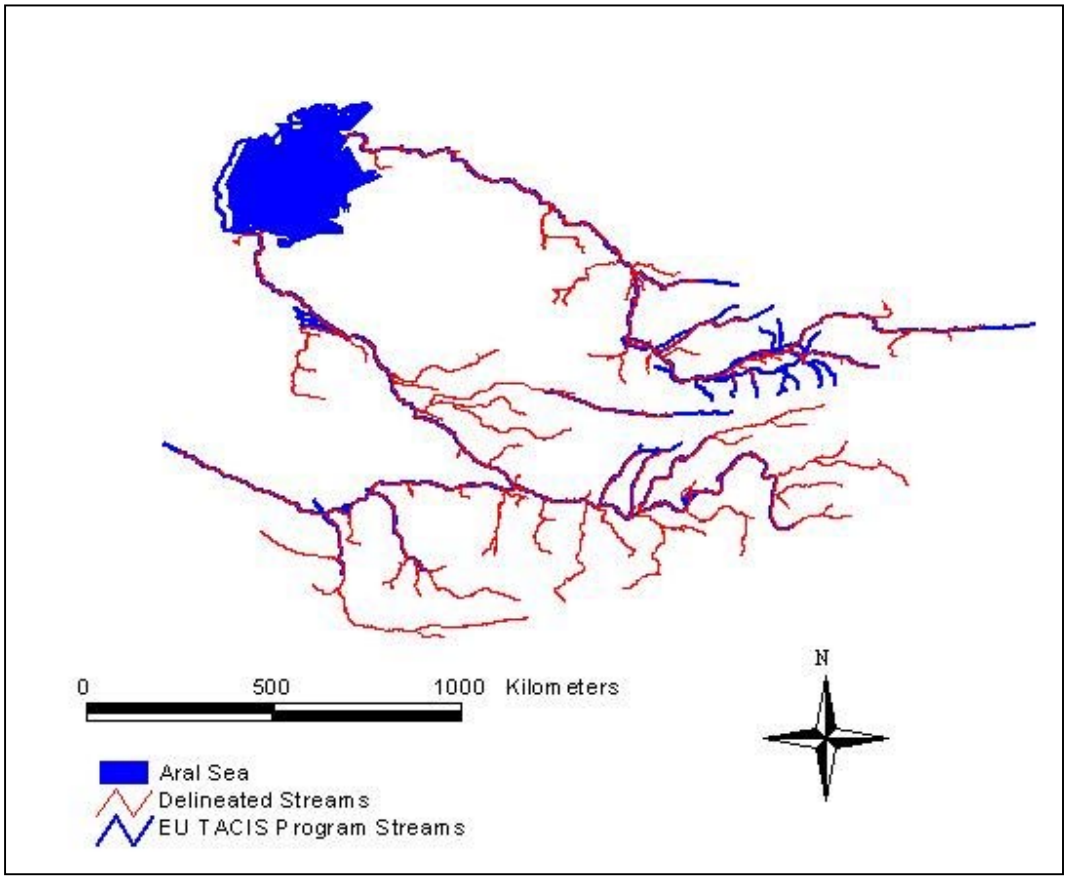

Figure 2.7: Comparison of the GIS delineated and EU TACIS Program streams for the Aral Sea basin.

Watershed Division

The Helsinki Rules list " the extent of the watershed within each country" as one of the 12 main topics to determine water rights. The ArcInfo intersect command was used to intersect the watershed coverage (Figure 2.6) with the political country coverage (Figure 1.1) to determine the watershed extent of each country. The results are interesting. Most of the Aral Sea basin lies within

Uzbekistan, Turkmenistan, Afghanistan and Kazakstan. The extent of the Aral Sea basin in China is minimal at 0.2%. The pie chart in Figure 2.8 illustrates the division of the basin more clearly.

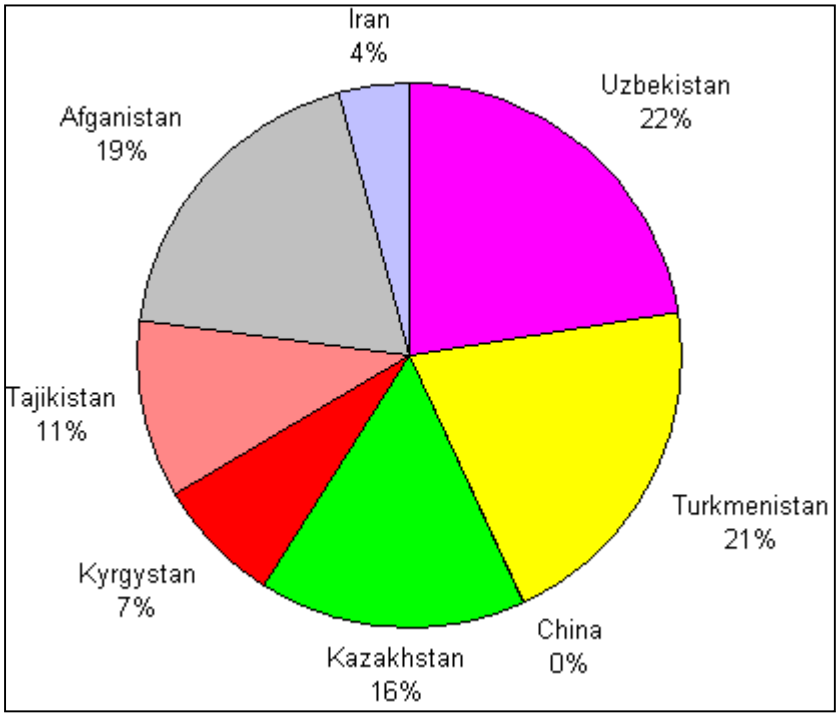

Figure 2.8: Percent of Aral Sea basin in each country.

The calculated values were then compared to documented values of watershed extent. The area of the Aral Sea basin referenced to January 1987 was found in the Diagnostic Study for the Development of an Action Plan for the Conservation of the Aral Sea (UNEP, 1991). Table 2.1 shows the comparison between the documented and calculated values.

Table 2. 1: Comparison of the Computed and Documented Areas of the Aral Sea Basin.

Country	Calculated % Watershed	Documented % Watershed
Uzbekistan	22.43	24.6
Turkmenistan	20.70	26.9
Kazakhstan	15.85	16.6
Tajikistan	10.70	7.9
Kyrgystan	7.37	7.0
Afganistan	18.67	13.4
Iran	4.26	3.6
China	0.02	0.0

Table 2.1 indicates the utility and reliability of using GIS to delineate watershed areas. One should note that the calculated values for the two upstream countries, Kyrgyzstan and Tajikistan, are lower than the documented values. However, the calculated values for the downstream countries, Uzbekistan, Tajikistan, and Turkmenistan, are higher than the documented values. In natural circumstances the flow pattern of water cannot cross the borders of watersheds, but in some watersheds water is not only flowing in a natural direction but it is also diverted to other areas for irrigation, domestic use, and industrial use thereby increasing the extent of the watershed (Hoogeven, 1997). In this case, GIS was used to calculate the watershed only according to the DEM, thereby giving a smaller watershed.

SOIL WATER BALANCE

The soil water balance of the Aral Sea basin has been calculated before, but never using GIS. By determining the soil water balance in Central Asia, the "contribution of water by each basin State" can be determined (Helsinki Rules). The soil-water balance is a simple accounting scheme used to predict soil-water storage, evaporation, and water surplus. This section discusses the methodology of adding snowmelt to the GIS soil water balance of the Aral Sea basin.

Input Data

In order to calculate a soil water budget of the area, data was obtained from the Digital Atlas of the World Water Balance (CRWR, 1997). The DAWWB contains 30" by 30"cells of precipitation, temperature, water holding capacity, and radiation data for the Earth. This climatology is largely representative of the years 1920 to 1980 with more weight given to recent ("data-rich") years (Legates and Willmott, 1990).

Global estimates of "plant-extractable water capacity" have recently become available on a 30 arcminute grid (Dunne and Willmott, 1996). As used in the Digital Atlas of the World Water Balance, the term plant-extractable water capacity is equivalent to water-holding capacity. One reason given for developing this global database was to eliminate the need for assuming spatially invariant plant-extractable water capacity in soil-water balance computations made over large areas. Information about sand, clay, organic content, plant rooting depth, and horizon thickness was used to estimate the plant-extractable water capacity.

Figure 2.9 shows the soil water holding capacity in millimeters for the Aral Sea basin. The land nearest the rivers has a much higher water holding capacity.

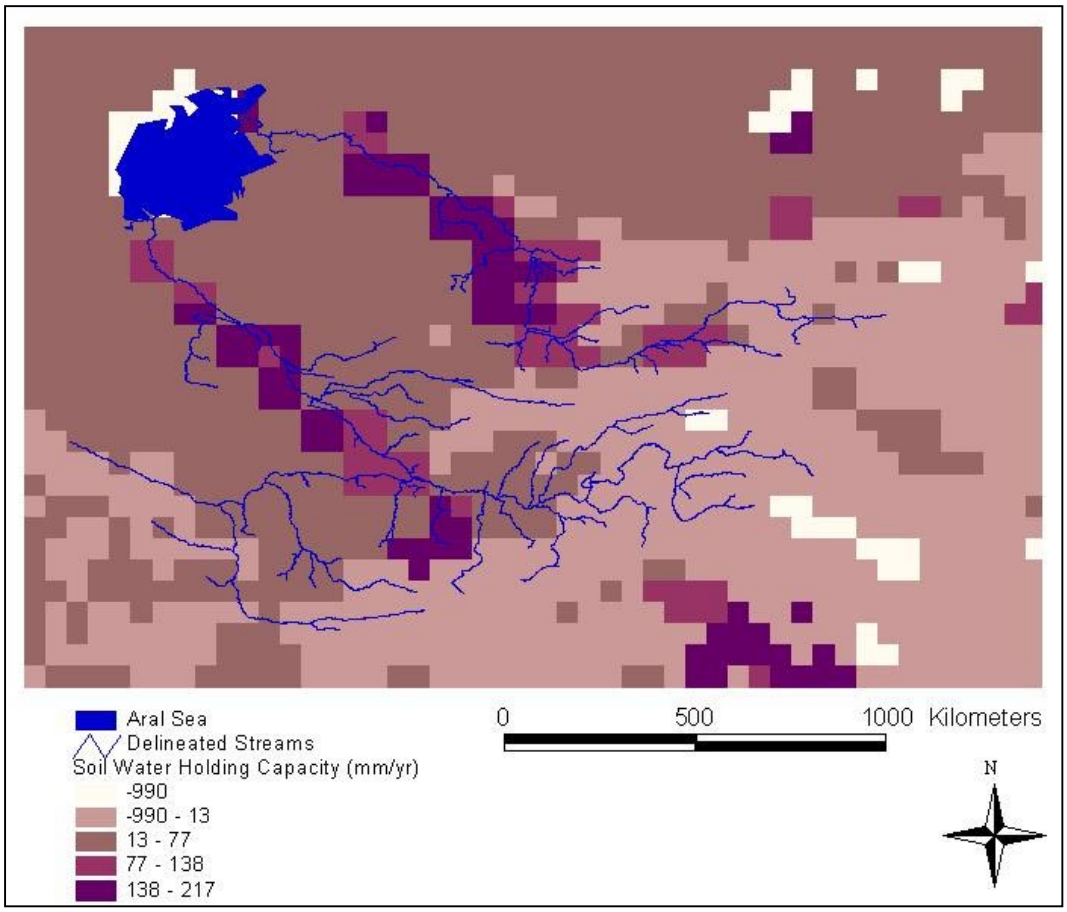

Figure 2.9: Soil water holding capacity of the Aral Sea basin (mm).

Figure 2.10 shows the average temperature in degrees Celsius for the area. The temperature in the mountainous areas has an average annual value of less than 0 degrees Celsius. This means that there are only a few daily temperatures above 0^{o}C when snow could melt. Meanwhile, the summer temperatures along the Amu Darya are desert like. Figure 2.11 shows the average annual net radiation in watts per square meter in the Aral Sea basin. The data set includes longwave and shortwave radiation flux estimates for a 96 month period extending from July 1983 to June 1991. Figure 2.12 shows the annual precipitation in millimeters. The region surrounding the Aral Sea receives very little precipitation throughout the year. The region surrounding the source of the rivers receives higher precipitation, mostly in the form of snow.

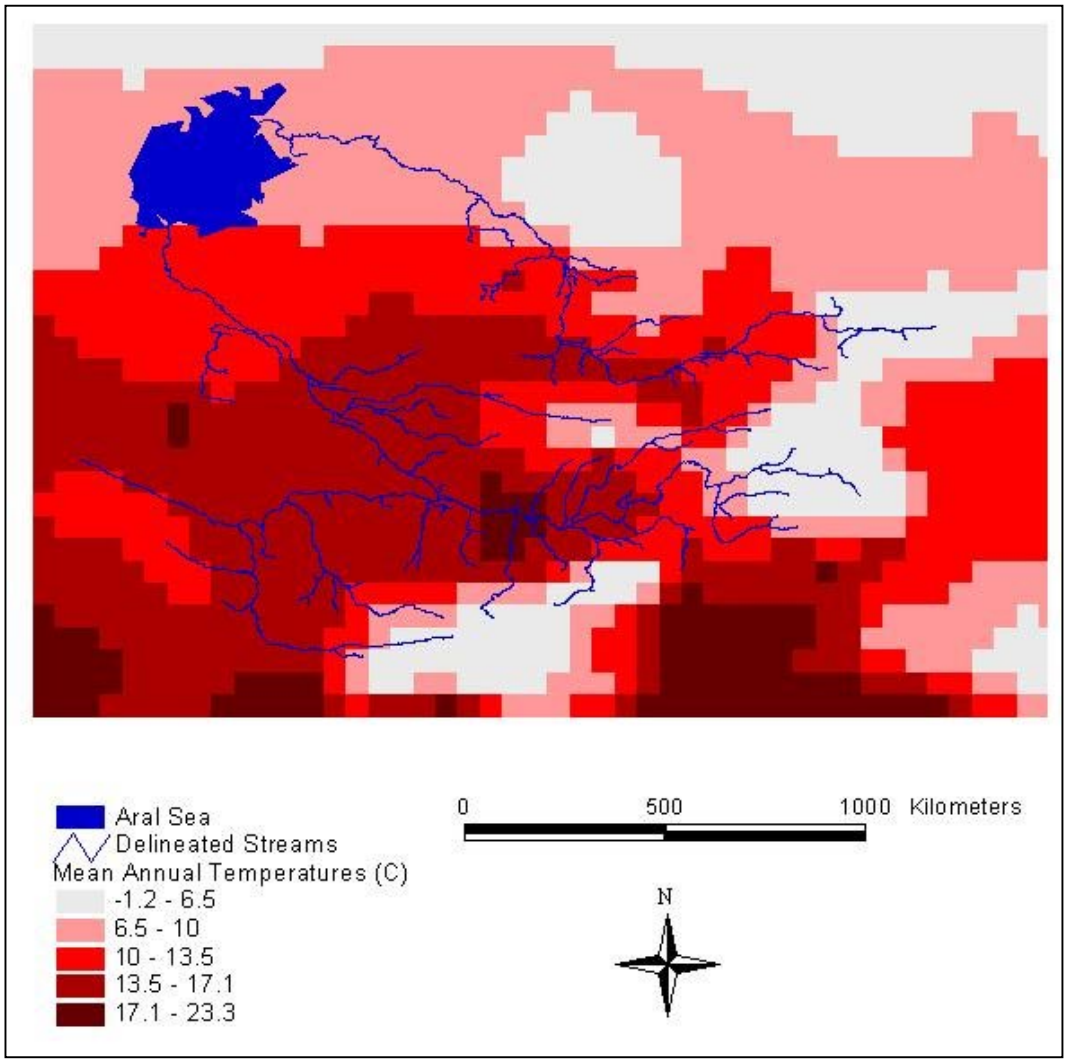

Figure 2.10: Average annual temperatures in the Aral Sea basin (^{o}C).

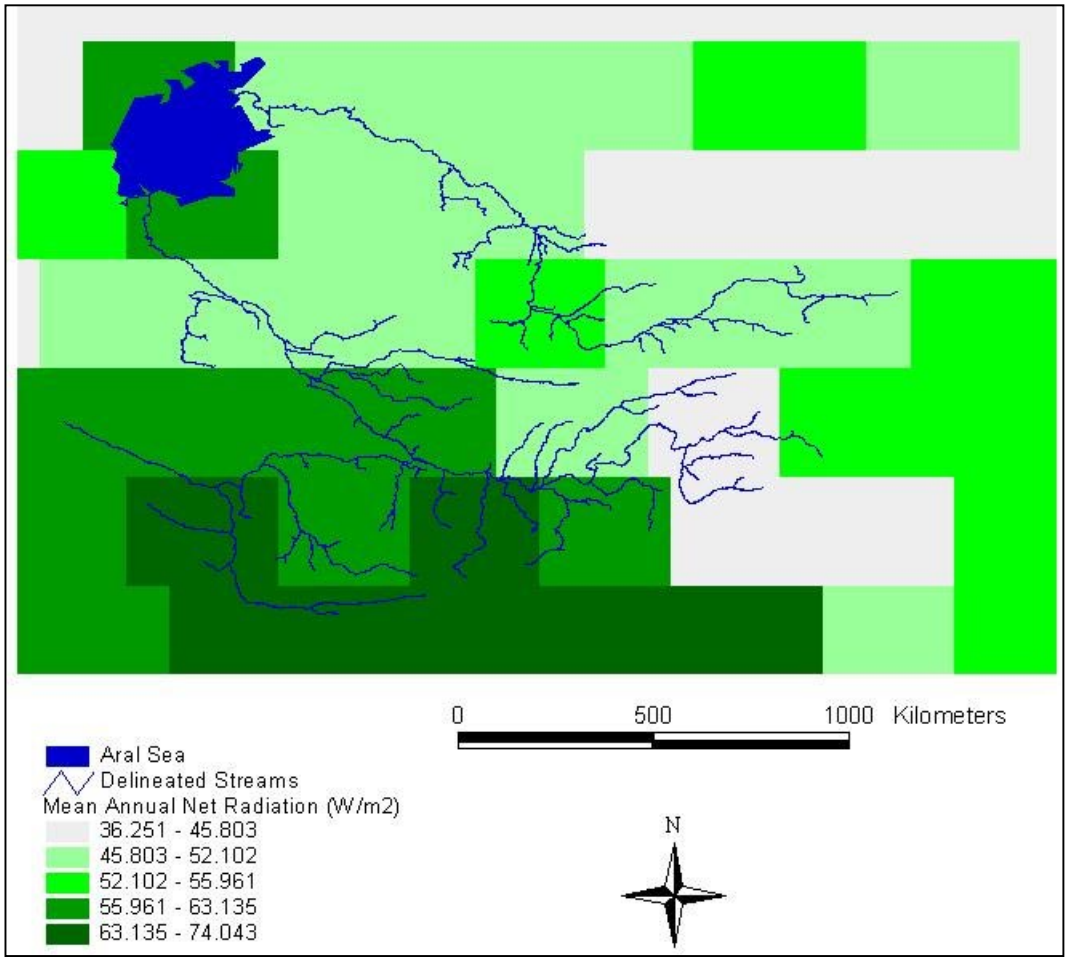

Figure 2.11: Mean monthly net radiation (W/m^2).

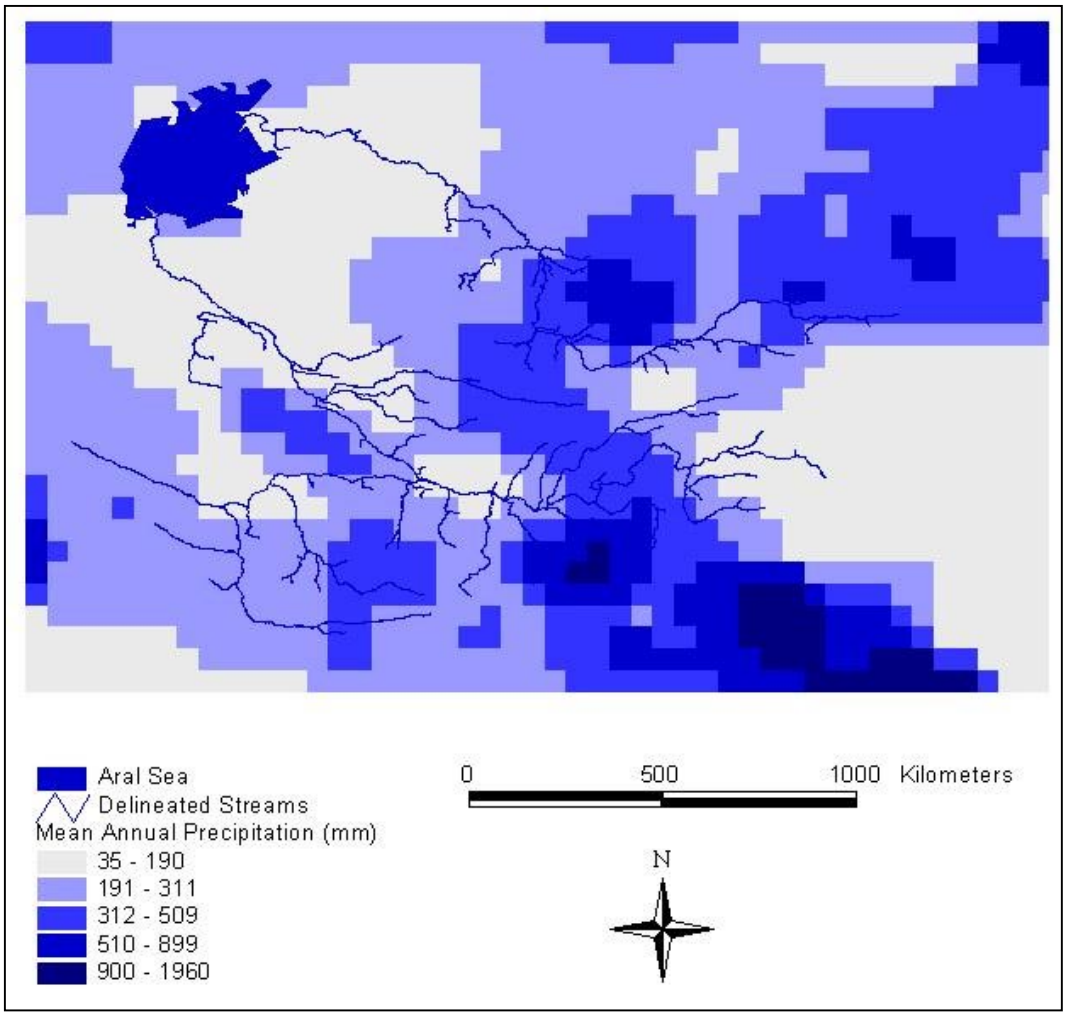

Figure 2.12: Mean annual precipitation in the Aral Sea basin (mm).

Methodology for Calculating Snowmelt

Geographic Information Systems (GIS) have been used extensively to study the spatial hydrology of regions. It is only fitting that those hydrologic studies be applied to political situations such as water disputes. The amount of water surplus produced by each country is an important hydrologic factor which can be determined using GIS. Several ArcView Avenue scripts were written at the Center for Research in Water Resources (CRWR) to calculate water surplus by Seann Reed. However, these calculations did not include water surplus from snow melt.

According to Aizen et al. (1996a) about 1,580 cubic kilometers of fresh water is stored in the central Asian glaciers. On average, glacial runoff is 10.3% of total runoff at the mouth of mountain valleys. This proportion of runoff decreases to 9.5% in wet years, and increases to 19.5% in drought years. It is therefore important to determine how to calculate runoff from snow melt for this study region.

Willmott et al. (1985) discussed the subject of water budgeting. The daily snow melt in millimeters per day is taken as

$$\text{Melt} = 2.63 + 2.55\,(\text{temp}) + 0.0912(\text{temp})(\text{rain}) \qquad (2.1)$$

This equation was fitted to three dissimilar drainage basins and 113 daily observations. Whitlock et al. (1985) estimate that the energy required to evaporate 1 mm/day of water is about 30 W/m^2. If energy is needed to evaporate

water, it can also be said that energy is needed to produce snow melt. However, Willmott et al. (1985) keep their equation for snow melt simplified by not introducing radiation into the equation.

There are two methods for calculating snowmelt according to Brubaker and Rango (1996), the simple temperature-index or the slightly more complex temperature and radiation. For the temperature-radiation approach, the general orientation of the hillslope is a major factor in the amount of solar radiation received, thereby further dividing the basin into "aspect/elevation zones". In the temperature version, the basin is "subdivided into elevation zones", where the lapse rate applied to a base-station temperature is used to obtain daily-average temperatures for the zone.

Brubaker and Rango (1996) discuss the development of the Snowmelt Runoff Model, which uses a temperature-index approach to melt snow from a basin's elevation zones. Air temperature is noted as being the best single meteorological variable for predicting snowmelt. Aizen et al. (1996b) state that air temperature alone can also be used a s a predictor of snow and ice melt in the Northern Tien Shan.

Brubaker et al. (1996) state that snowmelt forecasting models need to at minimum incorporate snowcover extent information, which is currently obtained operationally. This may create problems for large basins, and it is therefore concluded that the less data intensive temperature index models should be used for basins greater than 122,000 square kilometers.

In Brubaker et al. (1996), daily snowmelt is calculated according to the following equation

$$\text{Melt} = m_Q R_d + a_r T_d \qquad (2.2)$$

where m_Q [(cm/day)(W/m2)] is a physical constant converting energy to water mass or depth, R_d (W/m2) is the net radiation index, a_r (cm/day/^{o}C) is the restricted degree-day coefficient (the product of degree-day coefficient and degree-day index), and T_d (^{o}C) is the degree-day index. The basin is subdivided into elevation zones, and a lapse rate is applied to base-station temperatures in order to obtain daily-average temperatures for zones.

A precipitation module may also be used, along with temperature, to distinguish between the altitudes with snow and those with rain. In Brubaker et al. (1996)' s example, precipitation is labeled as snow for temperatures below 0.75 degrees Celsius.

Anderson (1976) recommends that snowmelt index models should keep the number of indices to a minimum, because of interrelationships between the indices. He concludes that the radiation and temperature indices are correlated, owing to the physical cause and effect relationships between net radiation and surface and air temperature.

Calculating Snowmelt

Soil water balancing refers to the partitioning of precipitation into evaporation, runoff and recharge using a water balance calculation applied to a volume of soil. A series of GIS computation scripts and exercises to determine the soil water balance have been developed and applied to the Aral Sea basin (Reed, 1997).

The soil-water budget is a simple accounting scheme used to predict soil-water storage, evaporation, and water surplus. Surplus is the fraction of precipitation that exceeds potential evapotranspiration and is not stored in the soil. The simple model used here does not distinguish between surface and subsurface runoff, so surplus includes both. The main purpose of calculating the water budget is to estimate surplus, which serves as input to groundwater and surface water flow models. With this in mind, the basic equation for calculating surplus is:

$$S = P - E - \Delta w/\Delta t \qquad (2.3)$$

where S is surplus (mm/mo), P is precipitation (mm/mo), E is evaporation (mm/yr), w is soil moisture (mm), and t is time (mo). Horizontal motion of water on the land surface or in the soil is not considered by this model.

The work of Reed (1997) did not include snowmelt in the water balance computations because temperatures throughout the study used remain above freezing throughout the year. In the Aral Sea basin, the average annual

temperatures can be as low as –1 C. It is therefore very important to incorporate snowmelt into the soil water balance computations. This has been accomplished with an enhanced version of Reed's ArcView scripts using Fortran (Appendix F).

The first step of calculating snowmelt is to determine whether precipitation was snow or rain. Accruing to Willmott and Dogg, snowmelt is equal to the following:

$$melt = 2.63 + 2.55\ (temp) + 0.0912(temp)(rain) \qquad (2.4)$$

where melt is snowmelt (mm/day), temp is temperature (^{o}C), and rain is non-ice precipitation (mm/mo). Precipitation partitions into rain and snow over the range from -1 to 4 degrees Celsius with essentially all precipitation being rain above 4 and all snow below -1 and in between a mixture of the two (Maidment, 1993). The snow budget was therefore run for two temperatures: 2^{o}C and 0^{o}C. The snow storage, Equation 2.5, at any time is equal to the snow storage at the time before plus the fallen snow within that time period minus the snowmelt, and the snow storage must always be equal or greater than zero:

$$sstor_{i+1} = sstor_i + snow - melt \qquad (2.5)$$
$$\text{If } sstor_{i+1} \leq 0$$
$$sstor_{i+1} = 0$$

where sstor is snow storage (mm/day), $sstor_{i+1}$ is the snow storage (mm/day) at next time increment snow is in millimeters per day, and melt in snowmelt (mm/day).

Results

The input data needed for the soil water balance are the monthly temperature, radiation, water holding capacity and precipitation grids obtained from the Digital Atlas of the World Water Balance, and the geographic extent of the watershed. The Priestley-Taylor method is used to calculate the potential evaporation and then the soil moisture balance is calculated. The final evaporation values for the area can be seen Figure 2.13.

As can be expected, the evaporation upstream in mountainous areas is low, while the evaporation values are high in the low plains. Some of the values in the mountain ranges have a negative evaporation. This is due to the area being covered with rock or ice. The Avenue program does not include equations for calculating evaporation with negative soil water holding capacities.

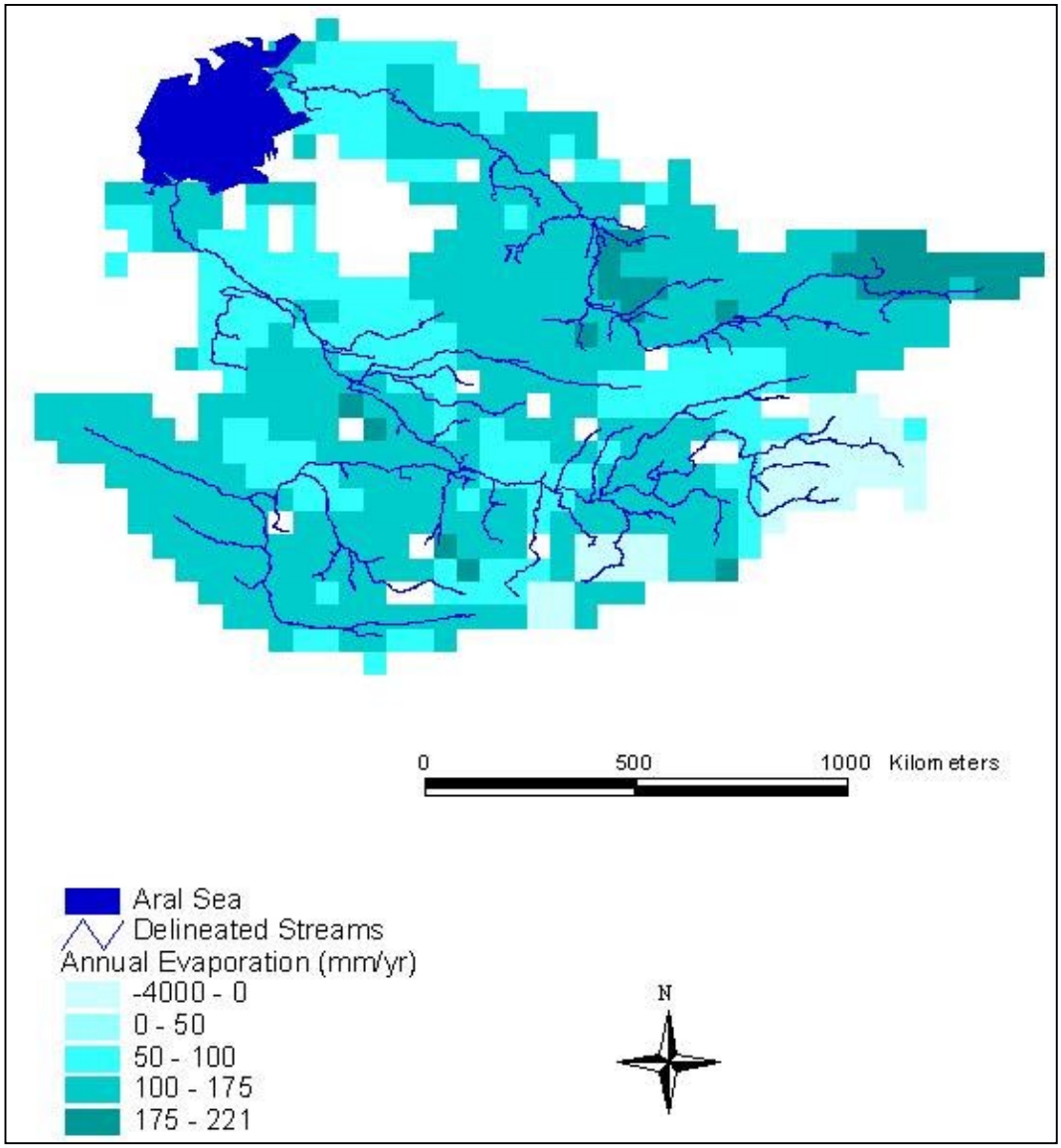

Figure 2.13: Annual evaporation in the Aral Sea basin (mm/yr).

Figure 2.14 shows the annual water surplus before the snowmelt component was added. Figure 2.15 shows the annual water surplus after the snowmelt component was added. This analysis was run using snow forming at temperatures lower than 2^{o}C. The water surplus using the snowmelt program is higher. Most of the snowmelt became runoff either because the soil was already saturated or because there is no soil at high altitudes, thereby increasing the water surplus. A few cells, shown in dark red, have extremely high surplus values because their soil water holding capacity is –10 (vegetation is absent i.e. rock) or –990 (indicates ice). The evaporation for these cells is calculated to equal zero, thereby giving extremely high water surpluses. Figure 2.16 shows the annual water surplus when snow is produced at 0^{o}C.

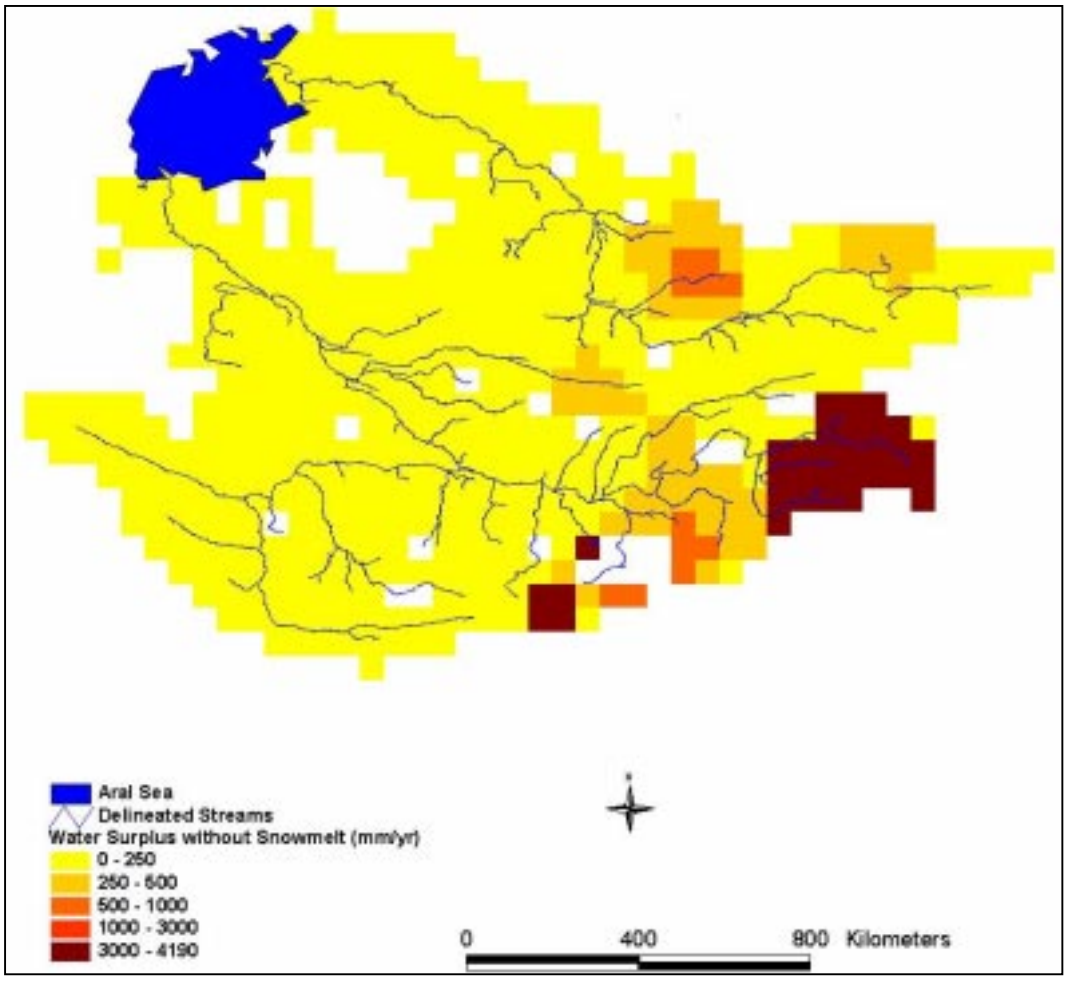

Figure 2.14: Annual water surplus in the Aral Sea basin without snowmelt (mm/yr).

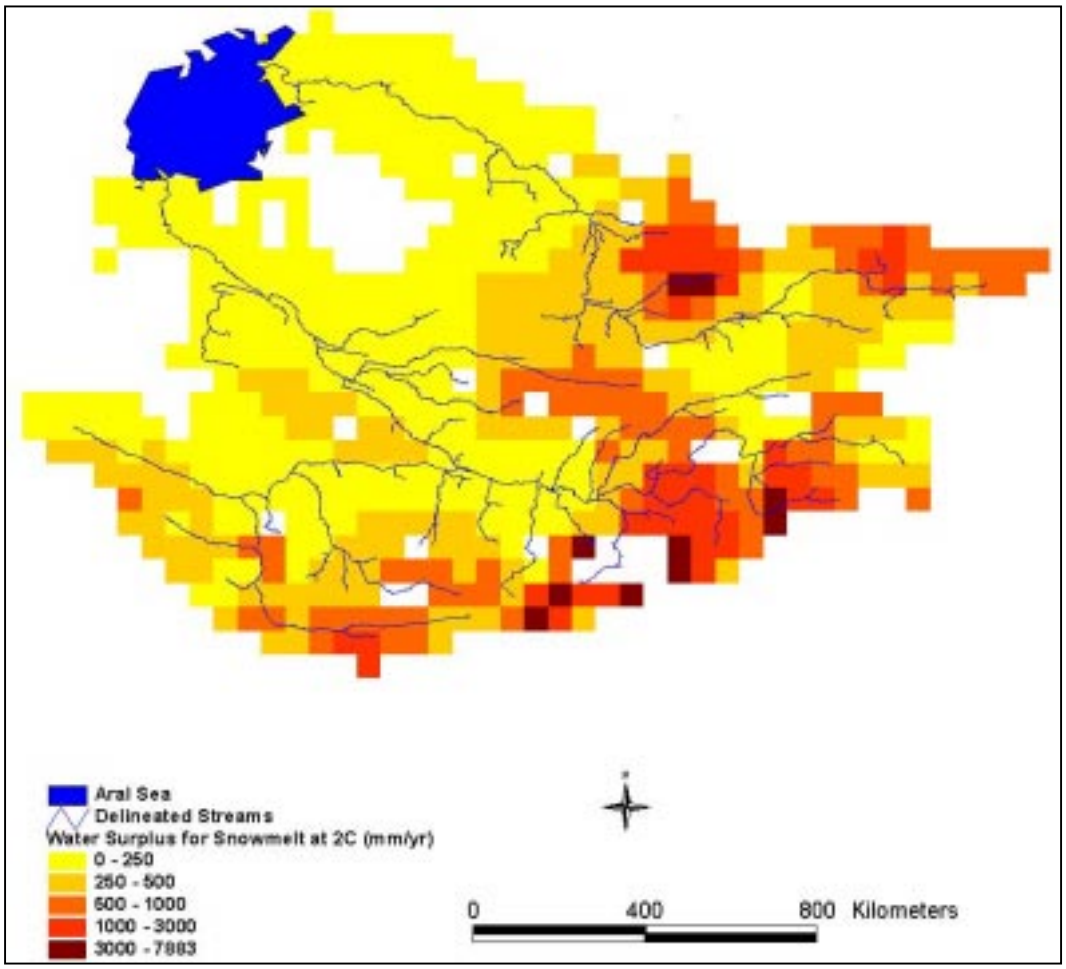

Figure 2.15: Annual water surplus in the Aral Sea basin with snowmelt at 2^{o}C (mm/yr).

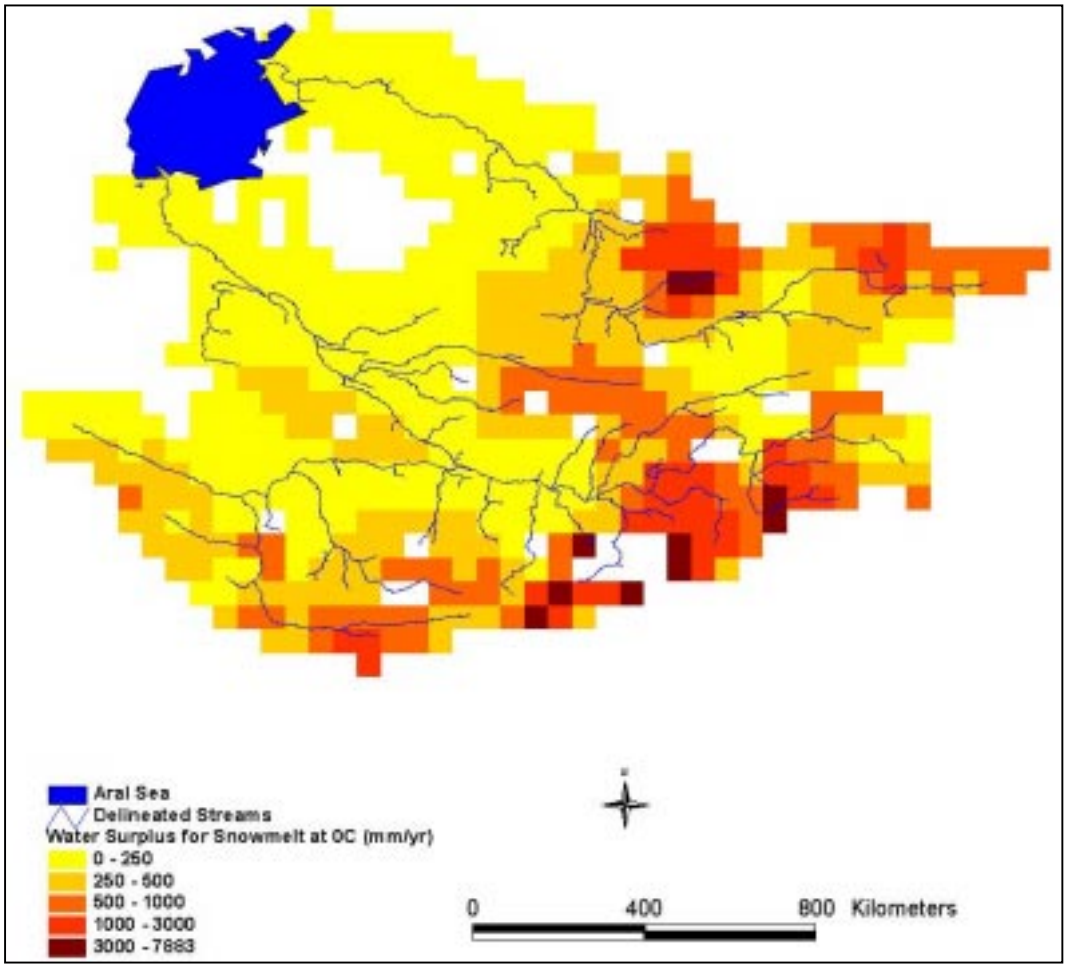

Figure 2.16: Annual water surplus in the Aral Sea basin with snowmelt at 0^{o}C (mm/yr).

The water surplus values differ for precipitation as rain, and for precipitation as snow and rain (Table 2.2). China's waters surplus differs by five times if snowmelt is calculated. The surplus for other countries differs by as much as 65%. When snow melts, the ground is usually already saturated, thereby giving higher surpluses when snow is considered separately than rain. However, the difference between water surplus from snowmelt at 2^{o}C and 0^{o}C are very slight and differ by less than 1 %.

Table 2.2: Annual Water Surplus for Different Snow Temperatures.

	Annual Precipitation	Annual Surplus	Annual Surplus	Annual Surplus
		no snow	snow at 2C	snow at 0C
	(mm/yr)	(mm/yr)	(mm/yr)	(mm/yr)
Kyrgyzstan	335	16	46	46
Kazakstan	267	12	31	31
Tajikistan	259	106	51	51
Turkmenistan	211	8	18	18
Uzbekistan	255	12	29	29
Afganistan	326	60	78	78
Iran	253	10	30	30
China	132	173	25	25

Figure 2.17 displays the results for the water surplus more clearly. The upstream countries produce more surplus from a smaller amount of precipitation than the downstream countries. This is caused by most of the precipitation in the upstream countries (mountains) not infiltrating into the soil as does the precipitation in the downstream countries (valleys and plains). The water surpluses for Tajikistan, Afganistan and China when snowmelt is not computed are 5 to 17 times higher than the surpluses for the other countries. This

demonstrates the necessity for differentiating between snow and rain, and for calculating snowmelt. Figure 2.17 and Table 2.2 clearly show that the water surplus calculated with snowmelt is the better representative of water surplus for regions with high mountains and cold climates.

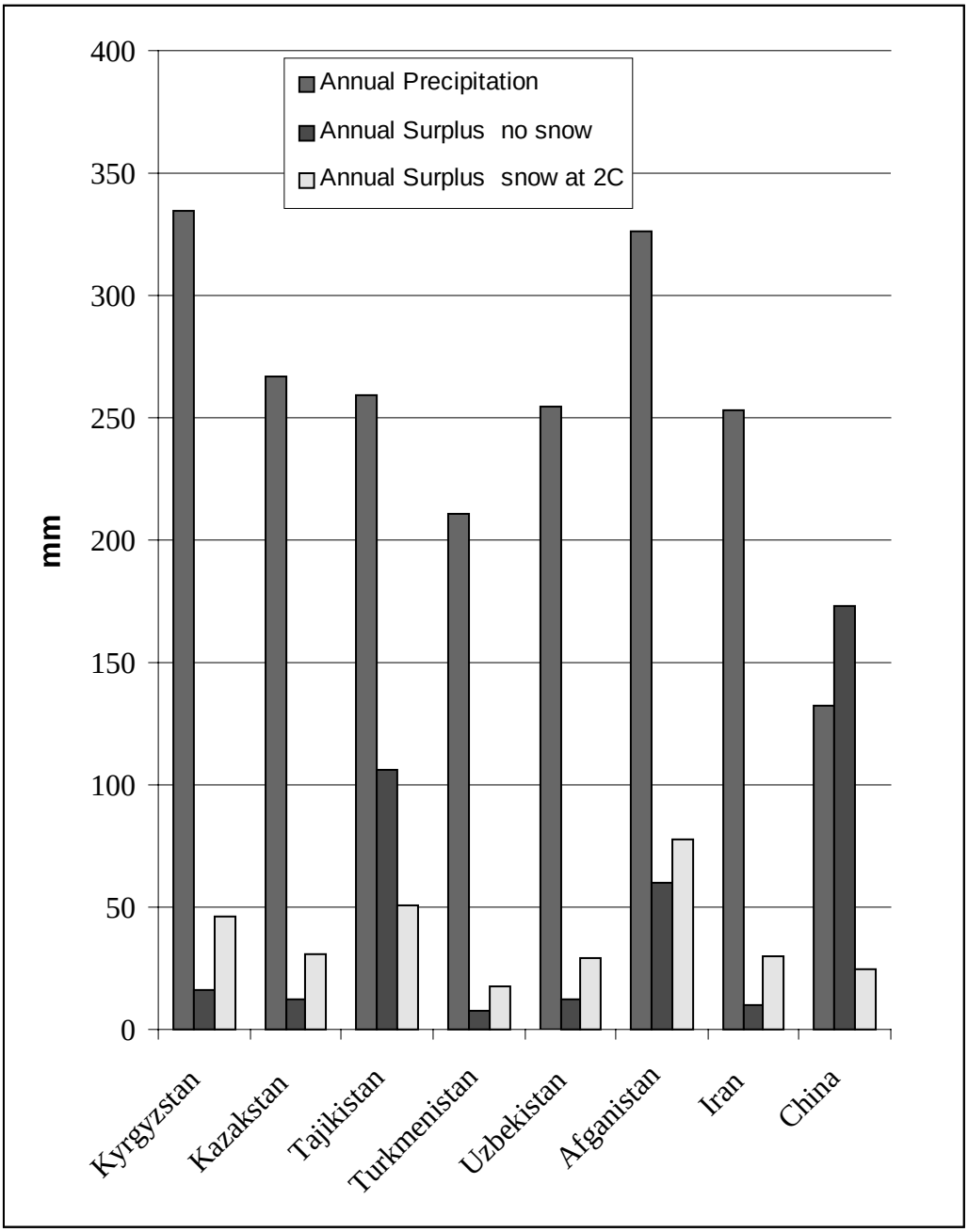

Figure 2.17: Precipitation versus water surplus for no snowmelt and snowmelt at 2^{o}C and 0^{o}C.

Because the Helsinki Rules list water contribution as one of the factors in determining water rights, it is important to establish where the surplus originates. Figure 2.18 is a pie chart which shows where water originates for water surplus with snowmelt. Afganistan, Tajikistan, and Kyrgyzstan are the countries that produce the most surplus. It should be noted that the surplus values for the mountainous areas may be slightly erroneous due to false evaporation values.

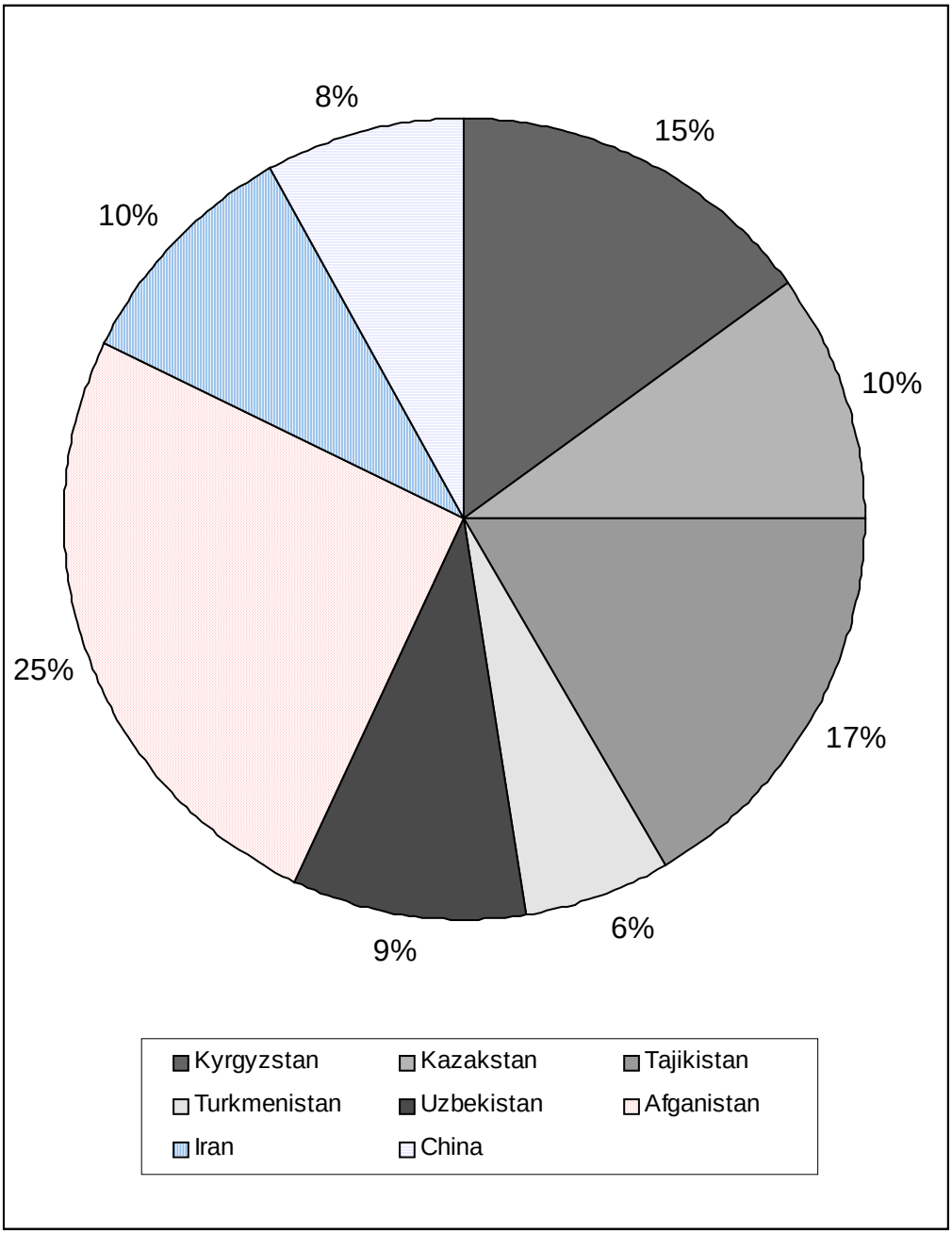

Figure 2.18: Pie chart for percent of annual water surplus for each Aral Sea country (snow at 2^{o}C and 0^{o}C).

Chapter 3: Social and Economic Study

There are three main factors dominating the complicated social and economic situation in the Aral Sea basin: the legacy of the past, the new political independence of each state, and the varying degrees of movement toward market-oriented economies (World Bank, 1996). Independence from the Soviet Union has brought the prospect of greater national-sufficiency and governance, while at the same time contributing to a decline in economic integration among the former republics of the USSR. Since becoming independent, each state has experienced high inflation, credit shortages and declines in the gross domestic product (GDP). However badly the economy has suffered, the levels of literacy, education and technical expertise have remained high.

The Helsinki Rules state that all factors in determining water rights must be weighed equally. Therefore, the economy and society of each Central Asian country must be analyzed in respect to their dependence on the Aral Sea waters. Chapter 3 is an in depth look at the economic and social problems each country faces. Chapter 4 addresses the matter of how to share the waters without hurting any or all of Central Asia's population's health and economies.

KAZAKSTAN

Introduction to Kazakstan

Geography

As of 1993, the population of Kazakstan was 17 million with a territory of 2.7 million square kilometers. Almost 3 million people live in the 302,000 square kilometers of Kazakstan's portion of the Aral Sea basin, the South Kazakstan and Kyzylorda oblasts. Kazakstan is a country of vast spaces and natural contrasts (Figure 3.1). When apricot trees start blossoming and grain is being sown in warm soil in the south, blizzards may be raging in the north of the country. The severe cold of Siberia and the oppressive heat of Asia, the taiga (coniferous forests) and steppe lands, vast lowlands and steep mountain ridges all meet on the territory of Kazakstan.

Almaty, or Alma-Ata, the capital of the Kazakstan, is situated in the southeastern part of the country at the foot of the Zailiski Ala-Tau mountain system. It is called a garden city. The word "Almaty" in Kazakh means "grown with apple trees", and "Alma -Ata" means "Apple Father". Almaty has a population of 1.3 million. Founded more than 130 years ago, this city is the youngest among the capitals of the world. However, the capital is in the process of being moved to the North of the country away from China and potentially hostile neighbors.

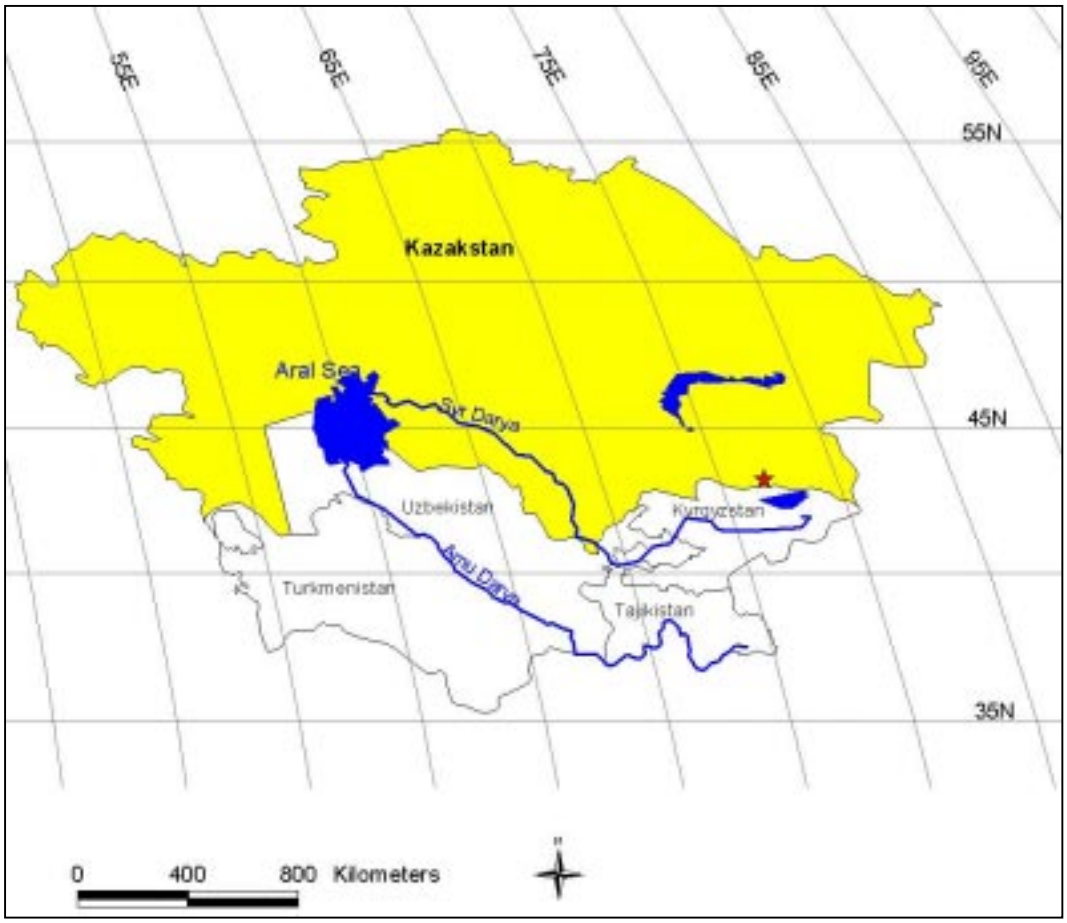

Figure 3. 1: Location of Kazakstan.

Covering a big territory, Kazakstan is one of the most sparsely populated countries in the world, 6.1 persons per square kilometer. There are 16.5 million inhabitants in Kazakstan today, Kazaks and Russians being the two ethnic majorities (Table 3. 1). Nearly 56% of the people live in towns and workers' settlements, the rest are the rural population (Kazakstan, 1997).

Table 3. 1: Ethnic Groups in Kazakstan

Kazak	4 %
Russians	6 %
Ukranians	%
Others: Germans, Tatars, Uzbeks	5 %

History

Administered as part of the Central Asia under the tsars, after the Bolshevik revolution Kazakstan became an Autonomous Soviet Socialist Republic (ASSR) within the Soviet Union. It did not achieve full republic status until 1936, and its borders continued to be shifted until the 1960s. Kazakstan was the last of the former Soviet republics to declare independence in December 1991 (Olcott, 12).

Kazakstan is a constitutional republic with a strong presidency. Throughout most of 1995, Kazakstan had no legislature; the country was governed through decree by the President and the Cabinet of Ministers. President Nursultan Nazarbayev, initially elected in 1991 to a five-year term as President, is the country's central political figure. In April 1995, his term was extended by referendum to the year 2000. A new constitution was adopted, also by referendum, in August 1995, that concentrates power in the presidency, permitting it to dominate the parliament, judiciary and local government.

The President is the head of state. He is also the commander-in-chief of the armed forces and may veto legislation that has been passed by the parliament. The Prime Minister, who serves at the pleasure of the President, chairs the Cabinet of Ministers and serves as Kazakstan's head of government. There are several deputy prime ministers (the number is not fixed), 20 ministers, and 19 chairmen of state committees.

Kazakstan has a bicameral parliament, comprised of a lower house (the Majilis) and upper house (the Senate). Forty members of the Senate are indirectly elected by members of the regional assemblies; the remaining seven senators are appointed by the President. The 67-seat Majilis is popularly-elected. The December 1995 parliamentary elections were considered to have been an important, albeit flawed, step on Kazakstan's road to democracy. Majilis deputies and the government both have the right of legislative initiative. In September 1996, Majilis deputies, for the first time, proposed several draft laws; prior to that time, all legislation considered by the parliament had been proposed by the government. Political parties in Kazakstan are generally small and nearly unknown outside of the major cities. There are six political parties officially represented in the Kazakstani parliament. Three of these parties - the Party of People's Unity, the Democratic Party, and the People's Cooperative Party - are pro-presidential. Two small opposition parties, the separatist and the communist parties, have seats in parliament. Outside of parliament, small Kazak ethnic and Slavic ethnic parties are active in some cities. Party affiliations play little role in local Kazakstani politics, where personal and family ties are more important.

Citizens enjoy basic rights to free speech, press and assembly; however, some rights are restricted by complicated bureaucratic requirements and an imperfect legal system. The government generally respects the human rights of its citizens. Citizens may therefore add pressure on the government to put restrictions on water use and install better techniques for water irrigation in order to save the Aral Sea. The health of Kazakstan's population is completely affected by the water pollution and salt storms, and therefore citizens may voice their concern for solving this problem. Furthermore, citizen's inputs into the planning process of water management could be important in developing sustainable water management.

Economic Needs

Six years ago, with the Soviet Union disintegrating around it, the Republic of Kazakstan literally discovered itself as an independent country. Since declaring independence on October 25, 1991, this Central Asian state has crafted the mechanisms and policies of a sovereign nation, paying specific attention to attracting foreign investment in its oil and gas sectors. Kazakstan today appears the most politically stable of the Central Asian states of the former Soviet Union. Kazakstan's President Nursultan Nazarbayev is widely viewed as an effective leader and reliable partner. By moving cautiously on the economic and political fronts, he has been able to avoid the doomsday scenarios of ethnic conflict, economic collapse, and renewed domination by Moscow. In achieving this stability, Kazakstan has attracted roughly $46 billion in foreign investment since independence, $9.5 billion more than Russia.

To its credit, since 1991 Kazakstan has been able to establish its statehood and national identity while coping with monumental problems associated with its Soviet legacy. These include environmental and public health crises from nuclear testing and a multi-ethnic population in which ethnic Kazaks formed only a plurality, not a majority, in their own country. The country also inherited a distorted economy heavily integrated with Russia but managed to solicit foreign investment and diversify by direct participation in the global economy.

The Kazakstani banking system is currently in a state of transition, and is trying to adopt Western banking standards. In the period 1993 to 1996, the number of commercial banks was halved, chiefly by failures, to just under 100. Local citizens are wary of the reliability of Kazakstani banks, as well as wary of tax authorities, and generally keep their savings at home. Kazakstani banks offer loans at prohibitively high interest rates, which often frustrate small, developing entrepreneurs. The volume of lending is low. The undercapitalization of Kazakstani banks means that they do not have the ability to finance major projects. Loans from Kazakstani banks carry a very high interest rate, often 20% higher than the refinancing rate. These high rates are set partly because the rates lag behind falling inflation and partly because the banks are trying to compensate for losses from past bad loans. The official National Bank of Kazakstan refinancing rate as of January 1997 was 35%, down from a high of 300% in March 1994 (BISNIS, 1997).

Social Needs

The transition of sovereign Kazakstan to a market economy has been accompanied by a production crisis and an unprecedented deterioration of the social sphere. The living standards of a significant portion of the population are declining, the material conditions of different groups are becoming polarized, and social services, especially in the sphere of public health care, are shrinking. The latter is due most of all to the state budget deficit and cuts in allocations for health services, which amount to a 40% drop in real terms (UNHDP, 1996).

As for the education sector, the overall picture has been one of decline. State expenditures for education were 55% lower in 1995 than in 1993. State funding for pre-schools is ending, with the result that between 1991 and 1995 half of all kindergartens and day nurseries were closed down. To compensate, private funding is being mobilized. Major education reforms are under way to improve school facilities, to revise curricula, and to reduce dependency on Russian-produced text books; but funding is still a major problem. Nevertheless, past achievements in the educational sphere mean that the country's educational level is still high, especially with regard to the literacy rate and average years of schooling.

The last stage of settlement on the territory of Kazakstan in the early 1990's was characterized by rapid growth of towns and cities as well as of the population itself, and explosive development of industrial potential in the most densely populated regions. One of the main consequences of the transition process has been a fall in the birth rate due to curtailment of third and subsequent births.

Another consequence has been rising mortality due to circulatory disease, accidents, murder and suicide, and cancer. Together these resulted in the decline of absolute natural growth from 256,100 per year in 1989 to 145,800 per year in 1994, a 43% fall. There has also been a substantial net emigration, mainly of Russians, Germans and Ukrainians.

The process of urbanization has resulted in a critical ecological situation in the principal regions where industrial development and population growth occurred. The most dangerous manifestations of this crisis are pollution of limited water resources and the atmosphere, degradation of the soil and vegetation, deforestation, extensive desertification, radiation pollution, and dangerous natural disaster situations such as the Aral Sea crisis. The Aral Sea ecological disaster zone caused by the drying up of this sea also has major consequences for the population of the area (oblasts near the Syr Darya) in terms of employment and health. On the other hand, the rise in the level of the Caspian Sea is also a major threat to the environment, and it is anticipated that it will flood 3 million hectares of Kazakstani pasture lands, towns and cities and industrial complexes.

The Aral Sea's contaminated with agricultural runoff containing salts, pesticides, and fertilizer residues have been the cause of many diseases. Only about 10% of potable drinking water requirements, where approximately 30 liters per day are considered required for basic human needs, area available in rural areas near the Aral Sea. The incidence of typhoid and hepatitis in the oblasts bordering the sea are five times the average for all of Kazakstan.

Qyzylorda, a region of Kazakstan bordering the Aral Sea, has an 84% greater death rate than the rest of Kazakstan; death caused by diseases of the circulatory system are 74% higher, diseases of the respiratory system are 148% higher, and malignant neoplasms are 72% higher in Qyzylorda than the rest of Kazakstan (Anderson, 1997). From 1985 to 1994, the rate of spontaneous abortions (miscarriages) in Qyzylorda has increased by 70%. In the districts of Aral and Kazalinsk Rayon, spontaneous abortions rates are 2 times higher than the birth rates.

Despite the decline in industrial production, and measures taken to protect water supplies, the level of pollution in reservoirs remains high. Construction of treatment works for the Irtysh River remains unfinished because of lack of funds. In addition, the capacities of existing purification plants for sewage in many oblasts cannot keep up with the volumes of water to be treated. Industrial waste from the mining industry currently amounts to 19 billion tons. Furthermore, only 6 to 7% of the one billion tons produced annually, are recycled, compared to the corresponding figure for developed countries of 40 to 50%.

The rapid rate and wide extent of impoverishment in Kazakstan has had a number of specific effects: The formerly low-income segments of the population (pensioners, the disabled, large families, unmarried mothers, people without a wage-earner in the household, etc.) have all become extremely poor and are now on the verge of destitution.

Most of the population (64 %) are living near or below the minimum subsistence level. Rural areas are serious concentration points for poverty. At

present 84% of the rural population have incomes below the minimum subsistence level defined by the state Statistical Committee. Agriculture, which employs the rural population, also employs 44% of the workforce. Therefore, the status as living below the poverty line of 37% of Uzbekistan's population is dependent on the Syr Darya. Unemployment has increased, and 70 % of the registered unemployed are workmen. Workers at industrial enterprises are experiencing great suffering. Many of them are on forced leaves or part-time schedules due to the absence of material resources and power, customer insolvency and lack of sales markets. State employees are in very serious need. Teachers, doctors and state white-collar personnel are the lowest paid; their salaries are a mere 40 % of the republican average. The poverty of all state employees is aggravated by constant delays in salary and pension payments. In March 1996, salary arrears equaled 2.7 times the state's entire monthly payroll, fund, and unpaid pensions amounted to 1.5 times the size of social benefits. New kinds of poor people have appeared: Refugees number approximately 150,000; the number of homeless people and drifters cannot even be estimated.

The United Nations Development Programme Human Development Report Office urges the Kazakstani government to determine which of the above groups have the highest priority, based on the gravity of their situations and the existing resources. It also urges the preparation of a clearly defined national poverty reduction strategy, made up of mid-term and long-term measures, and on the basis of models of economic growth which reflect flexible micro-economic policy. These models should have a multi-sectoral approach and must not

concentrate only on privileges and benefits. Economic methods of encouraging private initiatives, a reliable system of poverty monitoring, the participation of civil society, and greater regional independence in decision-making should also be included (UNHDP, 1996).

Dependence on Aral Sea Basin

A total of 44% of Kazakstan's 17 million population depends on agriculture as a source of employment. Currently 2.6 million Kazakstanis, hence 15% of the total population, live in the Aral Sea Basin (South Kazakstan and Kyzl Orda Oblasts) and more than 30% of the GDP is from agriculture. Kazkastan diverts 9.4 cubic kilometers of water per year from the Syr Darya and the Kirov Canal. The Interstate Commission for Water Coordination (ICWC), founded in 1992 to prevent conflicts in water distribution, and to manage the Syr Darya and Amu Darya, allocates 8.4 cubic kilometers of water per year to Kazakstan (World Bank, 1996).

In order to receive a critical 3.25 cubic kilometers of water yearly from the Toktogul Reservoirs and 1.1 billion kilowatt hour of hydroelectric power during the summer months, Kazakstan provides Kyrgyzstan with 1.1 billion kilowatt hours of electricity in the form of coal or electricity. These summer water releases are used to irrigate 302,000 square kilometers of Kazakstani land (Keith and McKinney, 1997).

Availability of Resources

Kazakstan has substantial oil, natural gas and coal reserves and major agricultural resources. It possesses immense mineral wealth and it is a major

producer of iron ore and a variety of non-ferrous metals (chromite, copper, zinc, and lead). Uranium is mined and processed, and nuclear research facilities and test sites are located in Kazakstan (in 1995 the republic completed its process of nuclear disarmament). Parts of Kazakstan are highly industrialized and factories are involved in the transformation of raw materials, including metal processing, fuel, power, chemicals, machine building, textiles, and food processing. Kazakstan is highly dependent on trade with Russia, and exchanges natural resources for finished consumer and industrial goods. The main agricultural crops are fruits, sugar beet, vegetables, potatoes, cotton and cereals, and livestock breeding and wool producing are also important. Over-intensive farming has resulted in the degradation of arable land.

The oil and gas industry is the most rapidly developing sector in Kazakstan. The country's proven oil reserves are 15.5 billion barrels, but potential reserves under the Caspian Sea could be enormous - perhaps more than 30 billion barrels. Estimates of natural gas reserves range from three to six trillion cubic meters. Current annual production is roughly 189 million barrels of oil and six billion cubic meters of natural gas. Kazakstan hopes to produce 630 million barrels of oil per year by 2005 and 950 million barrels by 2020 (BISNIS, 1997). To encourage foreign investment, Kazakstan has recently enacted a new tax code, established a new currency, the tenge, and stepped up efforts to stabilize its economy. Anxious to develop its vast resources, the government is also mindful of its environmental responsibility.

Oil production increased during the first nine months of 1996, reportedly reaching its 1993 level of 190 million barrels per year. Production during this period was 16 % higher than over the same period of 1995. Natural gas production also has grown, climbing nearly 27 % in the first three quarters of 1996 compared to the same period of 1995. The Energy Information Administration (EIA) of the Department of Energy (DOE) estimates that Kazakstan has proven reserves of 14 billion barrels of oil and 26 trillion cubic feet (tcf) of natural gas. One of the problems hobbling Kazakstan's economic recovery is the debt burden between enterprises - well over one billion dollars. The debt problem is particularly acute in the energy sector, with many private and commercial customers unable to pay for energy supplies. While officially recorded unemployment remains low, this masks a high level of hidden unemployment - perhaps close to 10 to 15%. By 1995, real domestic product had contracted to only 47% of its 1990 level. However, according to the government of Kazakstan, the steep decline in production finally may have bottomed out. GDP increased modestly in 1996 and is expected to grow by 2% in 1997. Western observers and international financial institutions concur with this view (BISNIS, 1997).

In 1995, Kazakstan's total energy production (66.7 billion kWh) was roughly comparable to production levels of the early 1980's. Energy consumption per person in 1995 was 4,424 kWh (1990 - 6,255 kWh). About 80% of Kazakstani energy is generated by coal-fired power stations. There are 54 coal-fired power stations, five hydro-electric power stations and one Caspian seashore-

based nuclear power station in Kazakstan. The Kazakstani power transmission and distribution system is linked to two separate networks: the Russian network in the north and the Central Asian system in the south. Although Kazakstan exports some of its electrical energy, it also imports approximately 30% of its electricity requirements. The vast majority of Kazakstani power generating equipment is out-of-date and in poor repair. Ninety-four % of Kazakstan's gas turbines, 57% of its steam turbines, and 33% of its steam boilers have been in use for at least 20 years. Kazakstan has traditionally used Russian-made equipment, and there is little Western-made heavy electrical equipment. The loss of energy during transmission and distribution is another serious problem. In 1995, energy losses reached 10.1 billion kWh, or 15.2% of energy produced. With most Kazakstani enterprises in financial difficulty, utility companies are rarely paid. In May 1995, debts to utilities exceeded 55 billion tenge (approximately $833 million) (BISNIS, 1997).

Kazakstan boasts one-third of the world's chromium and manganese deposits. Kazakstan also has substantial reserves of other minerals: 50% of the former Soviet Union's tungsten and lead, 40% of its zinc and copper, and 25% of its bauxite, silver and phosphorus. Kazakstan is also the largest producer among the Newly Independent States (NIS) of beryllium, tantalum, barite, uranium, cadmium, and arsenic. There is good gold mining potential in Kazakstan. More than half of Kazakstani mining, processing, and smelting enterprises have outdated equipment in need of repair. Most lack environmentally-friendly technologies. Kazakstan does not have its own indigenous mining manufacturing

industry, and is thus largely reliant on imports of mining machinery, mainly from Russia (BISNIS, 1997).

The importance of the Kazakh mining industry to the former Soviet Union is well documented. Approximately 30% of copper, 64% of lead, 46% of zinc and 99 % of chromite for the Soviet economy was produced in Kazakstan. However, the gold mining industry, particularly primary deposits and the production of dorè, was badly neglected under the Soviet centrally planned economy which instead concentrated investment in gold production in Siberia and northeastern Russia. Therefore, despite a long tradition of geological exploration identified numerous deposits, Kazakstan now lacks the capital to develop a gold industry and is actively seeking assistance from Western industrialized countries in the form of investment, technology and training. The Kazak Government appreciates the need to establish a competitive fiscal and legal framework to compete for foreign investment and is reportedly committed to making Kazakstan first among the emerging market economies in the competition for foreign investment. The progressive attitude of the Kazakh Government is best illustrated by the new "Gold Law" signed by President Nazarbayev on July 20, 1995 which permits the export of physical gold from Kazakstan. Western companies provided advice and suggestions to the Government as to the format of the "Gold Law" (Info Mine, 1997).

UZBEKISTAN

Introduction to Uzbekistan

Geography

Uzbekistan, 447,400 square kilometers of territory (see Figure 3. 2), is at the center of Central Asia's transportation and power systems. About three-fifths of Uzbekistan's land area is desert steppe broken by irrigated, fertile oases along the banks of two great rivers, the Amu Darya and Syr Darya. Uzbekistan has cold winters and averages no more than 8 inches of rainfall a year, but its hot, dry summers, extending from May through October, and water for irrigation, create excellent growing conditions for warm weather crops such as cotton, tobacco, fruits, and vegetables.

Uzbekistan has a population of 22 million people and Tashkent, located at the foothills of the Tien Shan Mountains, is the capital. Uzbek is the official state language, though Russian is as commonly spoken. Tajik is also the common language among persons of that nationality *(*Roy, 1997*)*.

Tashkent has a population of 2 million people and another 4 million people live in the surrounding areas. The Tashkent region also contains the country's most advanced manufacturing, nonferrous metallurgy and energy processing facilities, serviced by a highly educated workforce trained at nearby universities and vocational institutions.

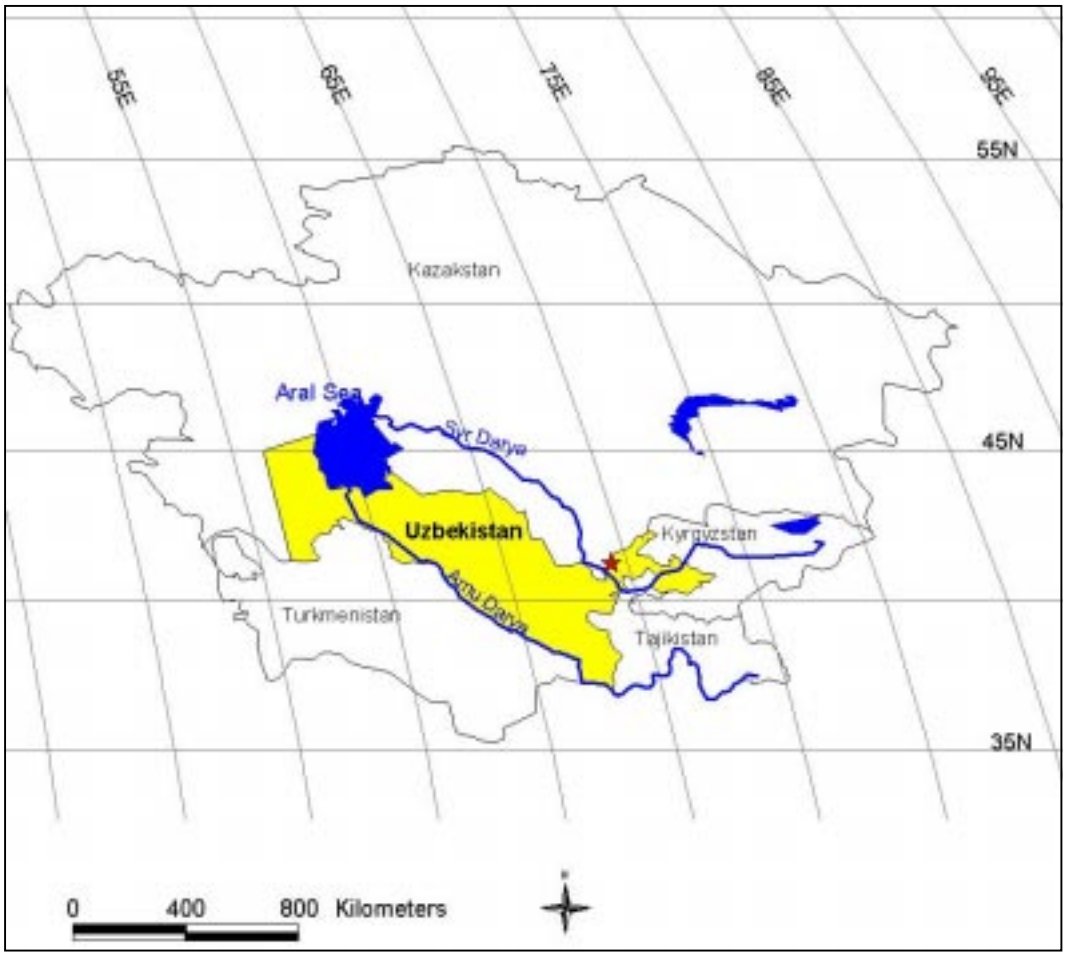

Figure 3.2: Location of Uzbekistan.

The fertile Ferghana Valley, the odd shaped tail projecting eastward from the main body of the country, contains six million people, including large minorities of ethnic Kyrgyz, Tajiks and Russians (Table 3.2). The Ferghana Valley produces a major share of the country's cotton and grain crops and also has numerous manufacturing plants, as well as natural gas and oil fields. The valley extends into parts of Tajikistan and the Kyrgyz Republic which are economically integrated with Uzbekistan and have large Uzbek minorities (Roy, 1997).

Table 3.2: Ethnic Groups in Uzbekistan

Uzbek	75 %
Russian	6 %
Tajik	4.8 %
Kazak	4.1 %
Tatars, Karakalpaks, others	10.1 %

Uzbekistan's central region consists mostly of desert, broken by the oases of the Zarafshan River, Qarshi Steppe, and Sukhandarya River. This region is best known for the ancient "silk road" cities of Samarkand and Bukhara which together claim more than 600,000 inhabitants and comprise the heart of Uzbekistan's tourism industry. Central Uzbekistan is also home to the mining center of Navoi and contains the majority of Uzbekistan's gold and other mineral deposits, as well as the largest natural gas and oil fields. Irrigation along the Amu Darya, Zarafshan and other rivers also provides a basis for agriculture.

In western Uzbekistan lie the ecologically damaged Aral Sea delta and the vast deserts which characterize the autonomous Republic of Karakalpakstan. Overuse of the rivers which feed the sea has already reduced it to two-thirds its former size and salinization of the area around the sea threatens the environmental and economic viability of a region in which a million people live. Blowing sand and salt from the dry beds surrounding the Aral Sea has the potential to dessicate agricultural areas downwind.

Despite Uzbekistan's rich natural resources and a skilled labour force, by the end of the 1980's, per capita income, labour productivity, and real wages

experienced a decline. Since 1991, reforms were initiated to reverse these trends and overcome their disruption caused by the break-up of the Soviet Union. The initial stages of reform have generated high social costs, but the government took the view that for reforms to succeed, it was necessary to reduce these high social costs. A decline in inflation has helped to stabilize incomes and the real value of social subsidies. Equally, special programmes undertaken by the government have helped to reduce infant and maternal mortality rates and produce an increase in life expectancy.

History

Russian military conquest of Uzbekistan began in 1865 and continued until the Uzbek Soviet Socialist Republic (SSR) was formed in 1924 from the former Turkestan ASSR and the Khiva and Bukhara people's republics. In 1925, the Uzbeks SSR was accepted into the USSR. The Republic of Uzbekistan proclaimed its independence on August 31, 1991 (Infopedia, 1996). Islam Karimov, the former head of Uzbekistan's Communist Party, was first elected President by Uzbekistan's Supreme Soviet in 1990 and later won a popular election in 1991. He now holds the leading post in the ruling People's Democratic Party (PDP) as well. On March 26, 1995 Karimov held a nationwide referendum to extend his presidential term until the year 2000 which officially passed with over 99% of the vote. Professing allegiance to what he terms "eastern democracy", Karimov has stressed the importance of political stability over Western-style democratic reforms. Although officially a multiparty system, the principal opposition groups including the Erk (Freedom) Democratic Party, the

Birlik (Unity) People's Movement (BPM) and the Islamic Renaissance Party (IRP) have been unable to register. The People's Democratic Party, government officials and a number of pro-government groups such as the Social Democratic Party Adolat (Justice) and the Vatan Taraqqieti (Fatherland Progressive) Party hold all the seats in the parliament (Oliy Majlis) (BISNIS, 1997).

Uzbekistan occupies a pivotal position in Central Asia: its frontiers are shared with Kazakstan, Turkmenistan, Kyrgyzstan and Tajikistan, but no great power, neither Russia nor China is a direct neighbor. Uzbekistan clearly detached itself from Moscow by being the only Central Asian state not to be occupied by a Russian military base. Islam Karimov has always refused to put Uzbekistan's frontier with Afganistan under CIS military protection. Instead, Uzbekistan's modest army of 35,000, where officers of Russian descent have been drastically reduced, protects the borders (Chetarian, 1997).

Economic Needs

In 1995, Uzbekistan achieved considerable success in macroeconomic stabilization. Measures taken by the government helped slow down the decline in production, led to a noticeable decrease in the inflation rate, encouraged investment, and contributed to the maintenance of a low state budget deficit. Institutional reforms and policies directed toward priority areas also helped to foster positive results, particularly in the oil, gas, and agricultural sectors. A substantial part of Uzbekistan's success derives from the government's macroeconomic policies. Unlike the governments of many CIS countries, the Uzbek government has rejected the shock-therapy approach. Instead it has

followed a slower, more cautious and balanced approach, so that the short - term goals of stabilization have not been so rigidly pursued as to strangle any potential for economic growth.

Taking 1990 as a base year, economic decline in Uzbekistan has been relatively moderate. Its level of GDP in 1995 was only 18.2% lower than its 1990 level. This contrasts with the dramatic drops in GDP (between 40 and 60%) that have occurred in surrounding CIS countries. The biggest drop in Uzbekistan's GDP occurred in 1992, when it fell by about 11 %. In comparison, the fall in 1995 was only 1.2%.

At the same time, the goal of limiting budget deficits to less than 3.5% of GDP has been achieved, and the government has also succeeded in directing 40 - 50 % of previous social cost allocations to current social needs. The proportion of the budget allocated to investment has increased from 3.9% of GDP (10.4% of total expenditures) in 1994 to 6.7% of GDP (18.4% of total expenditures) in 1995. Thus the current policy, combined with a functioning state apparatus, has helped to maintain and stimulate production growth in some sectors. This includes not only agriculture, but also energy and power, chemicals and petrochemicals, mechanical engineering, and metal-working. Moreover, the average monthly rate of inflation has decreased considerably and totaled only 6.7% in 1995 compared with almost 24.5% in 1994.

A substantial portion of the Uzbek population lives and works in rural areas. Forty five percent of the population work in the agriculture sector, while 55% of the population live in rural areas. Problems of excess labour supply in

rural areas have existed for some time and remain a priority issue in the country's economic reform. Compulsory employment, which occurred under the Soviet regime, was not conducive to improving human development or stimulating economic growth. At the same time, this policy did not create sufficient employment opportunities in regions with labour surplus, such as the Central Asian republics. The state artificially created the conditions for employment by encouraging the rural population to grow cotton. Visible unemployment did not exist because all individuals worked as collective farmers or employees of the sovkhozes. Low levels of labour productivity and incomes resulted from this policy. Since transition, the Government has tackled employment problems in conjunction with economic reform efforts, and the measures adopted have helped to generate employment opportunities, alleviate the threat of mass unemployment and decreasing individual dependency on the state. The drying out of the Aral Sea has caused further harm to the rural population's employment rates. However, for the period between 1996 and 2000, about two million new jobs will need to be created, and more than 950,000 people will need to be trained or retrained.

Social Needs

The reduction in state budgets for social services of health and education has had a critical effect on the level of services, causing most funds to be directed towards maintaining only minimal levels of health care. To offset reductions in state financing, non-governmental financing has increased, and a network of self-financing medical establishments has emerged, as well as pharmacies and clinics.

Furthermore, new mechanisms are being sought for health care financing reform, including through private insurance. While state funds continue to provide well over 80% of all health financing, the portion of health care financed by private means increased from 1.5% in 1990 to 5.8% in 1995, while the share of the total national budget devoted to health increased from 8.6% to 10.5% in 1994, largely for salaries.

In the education sector, despite limited budgets, the government is carrying out an ambitious programme to restructure the educational system, to train more teachers, to produce more text books, and to overcome the shortage of financing, by shifting part of educational financing away from the state budget to enterprises and students.

The development of an industrial society, a larger population, and greater affluence, have intensified pressure on the environment. Households now use far more energy from non-renewable resources in the form of electricity, gas, petroleum and other fuels compared to the Soviet era. Use of these resources has lowered the air quality. Household garbage today contains far more non-biodegradable materials than in the past, and re-usable waste is seldom recycled or returned to the soil. A higher population density, centralized water and sewage systems, and thermal power and gas have gradually turned houses into sources of environmental pollution. Counteracting the contamination of the environment requires tremendous financial resources.

Agriculture in Uzbekistan relies heavily on irrigated lands. There are 4.2 million hectares of irrigated lands, compared with 27 million hectares of

unirrigated lands. Recent analyses indicate that the quantity of irrigated lands suffering from low and medium levels of salinity has increased noticeably. In addition, drainage waters which flow into the Upper Amu Darya, when combined with the salinization of the soil in the upper layers, hamper agricultural production in a large portion of the Aral Sea region. Due to poor water resource management, and the absence of appropriate user fees, water consumption has tended to be high and inefficient. A result of this has been the progressive increase in the proportion of saline land to about 53%, and the fall in the level of the Aral Sea (Bortnik, 1992). Until very recently, over 90% of the population in the region relied on irrigation water for drinking water supply at least part of the year. As a result, the incidence of typhoid and hepatitis in the oblasts bordering the sea remains five times the average for all of Uzbekistan (Anderson, 1997).

Uzbekistan's neglect of the needs of the Karakalpak people has translated into a human tragedy of mounting proportions. With the desiccation of the Aral Sea has come health problems on an unprecedented scale. As of 1994, maternal deaths were 120 per 100,000 live births, and infant mortality was 60 per 1,000 live births, hence 40% above the rate of Uzbekistan (OneWorld, 1997). Studies show that of the 700,000 women there, some 97 percent are anemic with hemoglobin levels in their blood well below the World Health Organization's standard of 110 grams per liter. Five times the percentage of women affected a decade ago being the highest rate in the world (FAO, 1997).

There exists three types of poverty: income poverty (those with incomes which fall below a certain level of consumption), capability poverty (those who

lack the ability to live a lone life, enjoy good health, have access to knowledge, particularly vulnerable groups), and social deprivation poverty (where incomes and capabilities are unacceptably lower than the norms of their community). It is estimated that 44% of the Uzbekistan population fell in the category of poor during the period of perestroika, in terms of income poverty, and this increased to 75% by 1991, due largely to inflation during the period of perestroika. It has been relatively stable since then, as indicated by the slight reduction in crime rates since 1992 is an indicator (UNHDP, 1997).

The United Nations Development Programme Human Development Report Office put forward a set of seven proposals to reduce poverty in Uzbekistan :

- To reduce income poverty :
    - Resume economic growth, so as to assure more sustainable levels of incomes;
    - Emphasis should be placed on employment intensive growth, instead of relying on capital intensive energy and mineral sectors, so as to absorb the surplus labour in agriculture;
    - Promote small and medium-scale enterprises, and remove obstacles to their full expansion;
    - Establish a guaranteed employment scheme to provide productive employment to those working in declining sectors of activities.
- To reduce capability poverty :

- Invest in human capital through education and training, to reduce capability poverty;
- Strengthen health services, particularly of preventive health services, e.g. water, smoking, alcohol.

- To reduce social deprivation poverty :
  - Provide transfer payments to vulnerable groups, and/or community support groups to such groups (aged, disabled, women, children, etc.).

Dependence on the Aral Sea Basin

Twenty two million Uzbeks live in the Aral Sea basin (449,000 square kilometers). More than 36% of the Uzbek GDP is derived from agriculture, while 40% of all employment is in the agricultural sector. The increasing salinity of irrigated land in Uzbekistan has hampered production, thereby increasing rural unemployment.

The ICWC allocates 11.2 and 22 cubic kilometers from the Syr Darya and Amu Darya, respectively, to Uzbekistan. However, agrciculture consumes 60 cubic kilometers of water from the total 75 cubic kilometers of water resources in Uzbekistan (World Bank, 1997). In the Syr Darya basin, Uzbekistan also receives 3.25 cubic kilometers of water and 1.1 billions kilowatt-hours of hydroelectric power from Kyrgyzstan. Uzbekistan trades 400 million-kilowatt hours of power and 500 million cubic meters of natural gas for that water (Keith and McKinney, 1997).

Availability of Resources

Located at the very heart of Central Asia, Uzbekistan is the only country to border all five other republics. It is a compact country with a sizeable population which makes it a realistic base for local manufacture. Uzbekistan is the fourth-largest producer in the world of cotton, seventh-largest producer of gold, tenth-largest producer of natural gas.

Providing approximately 30% of GDP, agriculture continues to be one of Uzbekistan's highest development priorities. Within this sector, cotton production is predominant, making second largest exporter. Due partly to high world market prices, Uzbekistan's 1995 harvest of 4 million tons contributed 75% of its hard currency earnings and was instrumental in cutting the national budget deficit to approximately 4%. By the same measure, lower prices and a somewhat diminished yield in 1996 contributed to a $348 million trade deficit and jeopardized much of the progress of the previous year. Cotton is likely to retain its standing in Uzbekistan's economy if a $66 million World Bank loan approved in June 1995 is effective in improving yields. Cotton export outside of Uzbekistan remains under a state monopoly controlled by the Ministry of Foreign Economic Relations (MFER), though the government has reduced the level of state orders from 75% of the planned harvest in 1994 to a projected 30% in 1997. This would theoretically increase the portion of the harvest available to private farms for export within the CIS, assuming that they are able to exceed government production targets (which were not always met in 1996). Because farmers must sell their crops to MFER at government dictated prices, MFER can then sell the

same crops on the world market and keep the profits. Furthermore, the MFER gives subsidy to farmers for their crops and set the output quotas. This means that production decisions are not based on the price of inputs or outputs, thereby not encouraging the optimization of the Aral Sea basin waters.

The government has also boosted the amount of land dedicated to grain production in an effort to reduce Uzbekistan's dependence on food imports. Land under grain cultivation increased from 1.3 million hectares in 1995 to 1.7 million in 1996, whereas cotton cultivation since 1980 has fallen gradually to the current level of 1.5 million hectares. Despite the increase in land under cultivation, grain production fell short of government targets in both 1995 and 1996 with total yields of approximately 2.7 million metric tons each year. The 1996 shortfall was particularly damaging in that it combined with similar declines in Kazakstan, forcing Uzbekistan to import grain at very high world market prices and contributing further to the trade deficit noted above. Government plans to improve yields through gradual farm privatization and various agronomic reforms have yet to materialize.

Uzbekistan's nonferrous metals, particularly gold, already make a strong contribution to its export earnings. Currently producing approximately 70 tons of gold per year, Uzbekistan is the seventh largest producer in the world and (with only 25% of proven fields in production) contains the fourth largest reserves. In 1992, the Government of Uzbekistan entered into a joint venture with the U.S.-based Newmont Mining Company to produce an estimated 5 million ounces of gold over the next 16 years from the Muruntau mine. The government has also

entered into a $250 million venture with the British firm Lornho to extract gold in the Amantaytau region and the Kizil Kum desert. Other minerals which play an important role in Uzbekistan's economy include uranium, copper, zinc, tungsten, silver, molybdenum and lead . Currently the world's fourth largest uranium producer, Uzbekistan exported nearly $11 million in uranium concentrate to the U.S. in 1996. Copper production is also highly developed. The Almalyk mining and metallurgical works, near Tashkent, processes most of Uzbekistan's copper and zinc, currently generating approximately $300 million in copper and $10 million in zinc exports per year.

Uzbekistan possesses substantial hydrocarbon resources, particularly in natural gas, where it is among the world's ten largest producers. Most notable among Uzbekistan's natural gas fields are the giant Mingbulak and Kokdumalak fields currently yielding approximately 45 billion cubic meters of natural gas per year. In the oil industry, Uzbekistan has attained the distinction of being the only former Soviet state to enhance production since independence. Having doubled its 1991 production levels from 35 million to more than 63 million barrels in 1995, Uzbekistan has achieved petroleum self-sufficiency and is thereby able to avoid costly imports from Russia.

Electric power in Uzbekistan is derived primarily from natural gas-powered thermal plants with a smaller portion coming from coal and hydro-electric facilities. Uzbekistan currently possesses 11,000MW in electric generating capacity with plans for an additional 4,000MW through rehabilitation of existing and/or development of new plants. The largest natural gas-powered

facilities include the Syr Darya and Navoi plants. The coal-powered facilities consist principally of two power plants in the vicinity of the Angren open pit mine near Tashkent. Hydro-electricity is generated from 25 plants which together produce 15% of Uzbekistan's electricity. The Ministry of Energy hopes to boost Uzbekistan's electric generating capacity through a number of projects including an $81 million renovation of the Syr Darya plant using EBRD funds, the construction of a thermal plant near Termez, renovation of the Angren and Tashkent plants and the construction of a 400MW hydro-power plant in Pskent.

TURKMENISTAN

Introduction to Turkmenistan

Geography

Covering an area of 488,100 square kilometers, Turkmenistan is the fourth largest republic in the former Soviet Union and the second largest in Central Asia (Figure 3. 3). The Kara Kum desert comprises 80% of Turkmenistan's total area. The desert is bounded by a series of oases watered by the Amu Darya in the north and by rivers (the Murgap, Tejen, Atrek) descending from the Kopetdag Gershi and other mountains in the south. The central and western regions have no significant natural waterways, but the Kara Kum Canal brings water from the Amu Darya west to the Mary Oasis and onward to Ashgabat.

Turkmenistan has an extreme continental climate: temperatures in Ashgabat vary between 46^{o}C in summer and -5^{o}C in winter, although it has been known to reach -22$^{\cdot o}$C in extremity. Temperatures in the desert in summer can reach 50^{o}C during the day before falling rapidly at night. During the winter it can reach –10 to-15^{o}C.

Turkmen is the official state language, and is closer to Turkish, Azeri and Crimean Tartar than those of its neighbours, Uzbekistan and Kazakstan. The Turkmen script was changed from Latin to Cyrillic in 1940, but the process of changing back to the Turkish version of the Latin script is underway. Table 3.3 shows that Turkmen make up almost three fourths of the population (Roy, 1997).

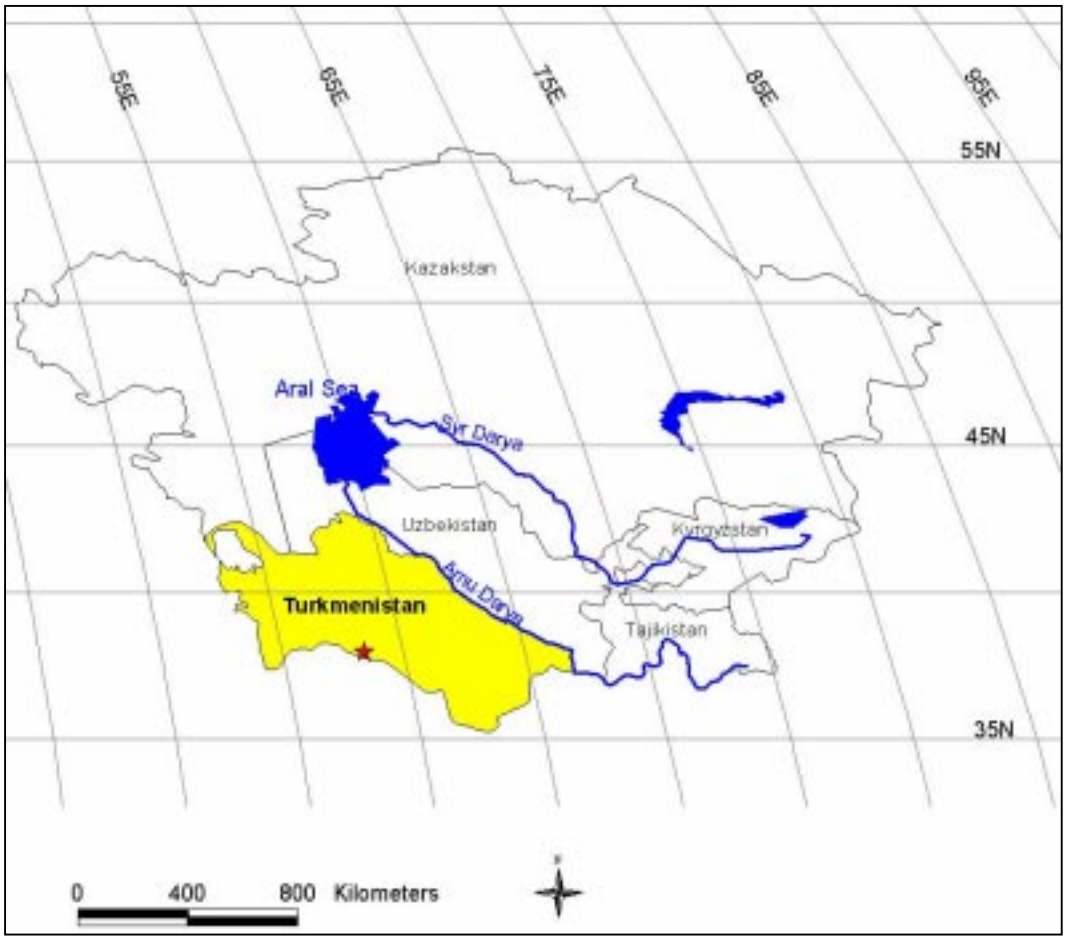

Figure 3.3: Location of Turkmenistan.

Table 3.3: Ethnic Groups in Turkmenistan

Turkmen	72 %
Russians	10 %
Uzbeks	9 %
Others:	9 %

History

Under Russian rule from 1881, the area initially resisted the Bolsheviks but fell to the Red Army by 1920. In 1925 the Turkmen Soviet Socialist Republic was formed from Turkmenian portions of Soviet Turkistan. In 1991 the republic's parliament declared Turkmenistan independent following a referendum; after the Soviet Union collapsed, the republic joined the Commonwealth of Independent States (CIS). The former Communist party has retained its hold on power in Turkmenistan, although there has been some movement toward privatizing the economy.

The current President is Sapurmurat Niyazov, who has been given the honorific title Turkmenbashi – leader of all Turkmen. He was elected President in 1992, having been Chairman of the Supreme Soviet since 1990, standing as the sole candidate. In a referendum in 1994 he was confirmed as President by 99.9 % of the eligible electorate vote.

Economic Needs

Over the last few years, economic development in Turkmenistan has been characterized by a decrease in the volume of production. This is the consequence of the gradual transition to a market economy which has been accompanied by changes in the economic mechanisms within and the economy. In 1994, national income was 80% of the level of 1990. This fall is due to decreases in natural gas extraction and the rise of agricultural prices. The speed of economic growth still depends on the volume of natural gas which is extracted and sold. The insolvency

of countries which purchase Turkmen gas is the main reason for the instability in the sector and the cause of the slowdown in the rate of extraction.

Another major priority being tackled by the government is the need to raise productivity in agriculture, and to carry out a gradual decrease in employment in the agricultural sector, and to use the majority of the work force in other branches of industry. The reorientation of some areas of the economy through the involvement of foreign partners is being strengthened. For this, foreign currency from the sale of mineral raw materials and oil products is being used.

The Government's programme "Ten Years of Stability" forms the foundation for budget policy in Turkmenistan and envisages a phased transition towards a market economy. This transition is not the main goal of economic development, but an important means of raising the living standards of the population. In Turkmenistan, economic reforms have a higher priority than political reforms, yet it is recognized that economic reforms can only be successfully realized when accompanied by political stability. The economic model selected by Turkmenistan envisages the preservation of strong state power, so as to not only provide guarantees for government macro-economic regulation of the economy, but also the provision of all conditions from the government's side for the successful realization of reforms. The government is striving to create a developed mixed economy, which implies the implementation of Turkmenistan's own model of economic management.

Although the share of agriculture in national income is 44%, industry (with 24% of national income, of which 67% is derived from fuel-energy) is considered the basis of the economy of Turkmenistan. With 1,600 enterprises employing 150,000 people, the role of industry since independence has increased. The main sources of wealth of Turkmenistan are oil and natural gas. In 1994, 35 million barrels of oil (including gas condensate) were produced. 35.7 billion cubic meters of gas were produced out of total gas extraction possibilities of 90 billion cubic meters per year. The country has the fourth largest reserve of natural gas in the world and 64% of total oil reserves in Central Asia. Annual gross revenues for oil and gas are expected to reach $7.3 billion and $13.7 billion respectively which more than cover the $5.5 billion anticipated for hydro-carbon extraction, refining and transport through pipelines.

Turkmenistan has a long agricultural tradition and a well established infrastructure. As a major producer of cotton and grain, and with good potential from food crops and livestock production (only 10% of suitable agricultural land is presently being farmed), the Government's New Agricultural Policy aims to increase production of these crops, and to be able to satisfy local demand for most types of food. This will be accelerated by the progressive privatization of farm plots and the attraction of foreign and domestic capital for joint ventures. Substantial progress has been made in providing the appropriate legislative framework for privatization and other economic activities, while maintaining the regulatory role of the government in this process.

While the high and stable population growth rate provides an annual growth of the labour force, it is estimated that the number of individuals entering the labour force is approximately four times higher than the number leaving. The closing of unprofitable enterprises, privatization and "demonopolisation" of property have contributed to a rise in unemployment.

Thus from 1990 to 1994, the labour force grew by 13.3% whereas the number of employees in the economy grew by only 8.3%. At the same time the employment structure of the economy has been changing, as evidenced by a 4.4 % reduction in employment in the public sector 1990 and 1994, a 1.3% reduction in the cooperative sector, and a 3.4% rise of the private sector. Moreover, during the same period, the number of employees in the productive sectors increased, while the number of employees in the public service sectors has decreased.

Social Needs

In 1992, the share of the budget dedicated to social purposes decreased dramatically. This decline was caused by the economic reforms in the country, the beginning of the transition toward market relations and the lack of budget resources. During 1991 to 1994, the expenditure on education and health increased while the expenditures on allowances and pensions were significantly decreased.

There has been a general deterioration in the health of the population, in spite of the high number of doctors (35 per 1,000). Also, inadequate attention has been paid to primary health care, as opposed to the maintenance of a large hospital infrastructure, with an excessive number of beds, and an occupancy rate

of only 72%. Major reforms of the health care system have been introduced, including the establishment in 1996 of a voluntary state medical insurance and a comprehensive Health Reforms Programme which was launched in mid 1995. This should contribute to adapting health care services and systems more effectively to needs.

The education sector has also been undergoing major reforms, as it tries to adapt to the needs of a market economy, and of the next century. It is the largest branch of the social sector, employing 47% of workers in the social sector, and receiving 61.5% of state budget expenditures allocated for social and cultural measures. Turkmenistan has achieved great success in education. By 1989, the level of literacy had reached 99.6%, and the number of workers with higher and secondary education is growing at an increasing rate. However, as for the health sector, a new education policy was introduced in 1993, with a view to adapting the education and training system to the future needs of the country. A similar process is under way with respect to science and technology, so as to reorient areas of priority from those required for the former Soviet Union, to those of the new state.

There are 425,000 pensioners (73% old age pensioners) in the country, or nearly 10% of the population. Five types of pensions are granted to eligible people (old age pensions, disability pensions, pensions for the loss of the bread-winner, social pensions for persons who have never worked and supplementary pensions). Insurance payments are compulsory for all workers. The result is that it has been possible to raise pensions, which is made easier by the low proportion of

pensioners. Problems have arisen due to the difficulties of targeting state assistance to the most needy populations.

A number of measures are urged to improve the existing system of pensions on an equitable basis, including improved targeting for low-income families. In summary, recommendations for a poverty prevention strategy in Turkmenistan include:

- Increase the system of social assistance to the poor particularly by improving targeting of beneficiaries;
- Improve the management system of social protection;
- Activate employment incentive system; and
- Expand sources of financing for the system of social protection, particularly from no-state funds.

Demographic trends in Turkmenistan are different from those in other CIS countries in that they have been characterized by a dynamic increase in the population, presently 2.5% per year, primarily because of the high rate of natural growth. The high fertility rate of 4.5 children per mother, and the consistently high birth rate averaging 33 births per 1000. Migration has also played a significant role, through the emigration during the period 1991 to 1995 of about 43,500 people to other republics of the former Soviet Union, of whom in 1995 72.2% were ethnic Russians. Among these, most were military personnel. The rate of migration was highest among specialists with higher or secondary technical education.

However, the Aral Sea crisis has crippled the health of Turkmenistan. In Nukus, cancer of the esophagus, which can be linked to diet as a well as environmental factors, is about six time the average in Turkmenistan. The Dashkovsky region, though not physically bordering the Aral Sea, is the closest part of Turkmenistan to the sea, has a infant mortality rate of 52 per 1000, while the rest of Turkmenistan has 58 per 1000 rate (Anderson, 1997).

The issue of poverty in Turkmenistan, as in the other post-socialist countries, was not a pressing matter in the past. In the old system, income distribution was more even, employment was guaranteed, and a broad system of social protection provided social support for families with many children, people with disabilities and other vulnerable members of society. Western specialists estimated that indices of inequality in the republics of the former Soviet Union were similar to those for countries of the Organization for Economic Cooperation and Development (OECD), and that the population that fell under the category of poor was less than 7%. However, the situation changed sharply with the beginning of the transition to a market economy. There is an increasing income disparity and stratification of the society into rich and poor. Price liberalization, for example, resulted in further deterioration in real incomes of the relatively poor people. The existing system of social protection could not adjust to new economic conditions and high inflation and could not provide adequate social assistance to the vulnerable segments of the population. These factors have created a condition of increasing poverty among the most vulnerable segments of the population.

In Turkmenistan, the main factors of potential poverty are family size, number of dependents, wage differentials, age, unemployment and the increase in the cost of living. These need to be taken into consideration in the implementation of a poverty prevention strategy in order to achieve sustainable human development. Turkmenistan relies deeply on agriculture both for food and for work. The agricultural sector itself is dependent on the waters of the Amu Darya for irrigation, thereby making the management of the Amu Darya a priority for the country.

The macro-economic policy of the country is very important as a means of preventing poverty for certain segments of the population. A correlation is known to exist between a change in real GDP and the proportion of poor people. In the period between 1987 and 1993, the GDP of Turkmenistan declined by 14 %, which is smaller than the decline observed in Kyrgyzstan and Kazakstan (21 % and 30 %, respectively). Accordingly the share of the poor in Turkmenistan increased fourfold from 1987 to 1994, which is also smaller than the increase in Kyrgyzstan and Kazakstan (6.3 times and 10 times, respectively). In 1993, it is estimated that the percent of the poor in Turkmenistan was 48% compared to 12% in 1987, while that for Kazakstan was 50% compared to 5% in 1987 and for Kyrgyzstan, 76% compared to 12%. Strikingly, neighbouring Uzbekistan with a 0% change in GDP between 1987 and 1993, had 29 % of its population estimated as poor compared to 24% in 1987.

The former high levels of opportunity which women enjoyed during the Soviet period, and the high status they were granted due to their high educational

training and their substantial role in socioeconomic spheres, have been continued during the transition period. A wide range of rights has been maintained unlike in other countries of the former Soviet Union. The high rates of women's employment (41% of blue and white collar workers [compared to 39.5% in 1970];47% of industrial workers; and 46% in sales and public catering) are impressive. Women also accounted for 36% of those employed at management levels and in administration, and 18% of positions in Parliament. However, the transition to a market economy has resulted in a reduction of staff in many non-industrial sectors, and women have often been vulnerable to industrial layoffs and their share in the total number of workers and employees fell from 4 % in 1990 to 41% in 1994. Women comprise 40% of those looking for jobs.

Turkmenistan's arid climate and limited water resources, have obliged it to invest heavily in reservoirs and irrigation systems for agriculture. The Amu Darya feeds water to the Karakum canal, the largest irrigation canal in the world, which runs for more than 1,100 kilometers across the southern part of the country and irrigates 900,000 hectares of land, out of a total of 1.6 million hectares of irrigated land. More than half of total agricultural production is produced in the canal zone, which also provides water for most of the large industrial cities. The agriculture output from this land contributes to more than 11% of the GDP. In Turkmenistan, 90% of the water consumed, hence 23 cubic kilometers per year, is used for irrigation.

About 80 % of the country, mainly the northern and central parts, is desert. Of the area suitable for irrigation (17 million hectares), only 10% are presently

under irrigation, through a massive network of 39,000 kilometers of canals, and a drainage system of 35,000 kilometers in length. Salinisation or the high level of subsoil waters have affected about 42% of the area making agriculture production plunge.

Air pollution is a significant problem in certain areas, due to industrial emissions and that from vehicles. Water pollution has been a serious problem in the Amu Darya, due to inflows of sewage and drainage salts from irrigation. Further environmental problems which affect Turkmenistan relate to the falling waters of the Aral Sea, starting in 1960, and the rising waters of the Caspian Sea (26.5 meters to 29 meters), starting in 1978. Both have necessitated concerted international action and reflection. In addition, the country is faced with the continual threat of natural disasters from earthquakes, floods, landslides, and dust storms.

Dependence on Aral Sea Basin

Turkmenistan has the largest area of all the countries in the Aral Sea basin, 492,000 square kilometers, where 4.5 million Turkmens live. The ICWC allocates 22 cubic kilometers of water per year to Turkmenistan. Turkmenistan's total water consumption is 23.8 cubic kilometers per year, making it extremely dependent on the Amu Darya.

Agriculture makes up 50% of the GDP and employs 45% of the workforce. The salinisation of the upper layers of soil has greatly affected the rural community's production and employment threatening Turkmenistan' s position as the world's 10th largest producer of cotton. Turkmenistan has a 60%

rural population depending on agriculture as a source of employment. Meanwhile, 80% of Turkmenistan's GDP is from industrial production. Of that industrial production, 33% is hydroelectric power from the Amu Darya.

Availability of Resources

Turkmenistan is destined to become one of the world's principal suppliers of natural gas in the 21st century. Turkmenistan has the world's fourth largest known natural gas reserves, after Russia, the U.S. and Iran, with proven reserves totaling 113 trillion cubic feet or 4 trillion cubic meters. The country has rich deposits of other minerals. Chief among these is oil. The Energy Information Administration (EIA) of the Department of Energy (DOE) estimates that Turkmenistan's proven reserves range from 0.8 to 1.4 billion barrels of oil and 102 to 189 tcf of natural gas (EBRD, 1997). However, there are also significant deposits of sulfur, potassium, and rock salts. Turkmenistan is one of the world's ten largest producers of cotton and is developing a textile industry. The country is situated at the heart of a developing trade region encompassing Russia, the Middle East, Turkey, the trans-Caucasus and the Indian sub-continent. The country has a major port on the Caspian Sea, Turkmenbashi. Although still at an early stage of transition from command to free-market economy, the country is expected to carry through reform over the next few years.

In 1995, Turkmenistan exported 23 billion cubic meters of natural gas, down from a high of 86 billion cubic meters in 1989, through Russian-controlled pipelines to CIS markets. Turkmenistan is actively pursuing other pipeline options

to Turkey, Pakistan and China. Turkmenistan also has 1.4 billion barrels of proven oil reserves. Many of the known reserves were undeveloped during the Soviet period due to limitations in technology and export routes. Turkmenistan is self-sufficient in electricity and exports about 25% of its 13 billion kwh to its neighbors, often in barter arrangements (BISNIS, 1997).

Agriculture plays a major role in the country's economy, accounting for nearly half of Turkmenistan's Gross Domestic Product and more than two-fifths of total employment. Turkmenistan's favorable climate and long growing season makes it suitable for growing cotton and a variety of other crops including grains, vegetables, and fruits. There is also considerable livestock raising. Little food is processed in Turkmenistan, and what is grown often spoils because of inadequate harvesting. Turkmenistan imports large quantities of grain, milk and dairy products, and various other food staples. The government, hoping to make Turkmenistan self-sufficient in food by the end of this decade, is currently investing in dairy and sugar processing plants and equipment. Cotton is and will continue to be Turkmenistan's most valuable crop, earning foreign exchange for the economy. However, the amount of land devoted to cotton production may be reduced in the future due to the government's attempt to diversify its agricultural industry (BISNIS, 1997).

TAJIKISTAN

Introduction to Tajikistan

Geography

Tajikistan is a small country, shown in Figure 3.4, 93% mountainous and covering 54,000 square miles. It is made up of a number of distinct and relatively isolated regions separated by high mountain ranges. Some of these regions are more closely linked economically to neighboring countries than to one another. The population is highly concentrated in the western half of the country as the eastern half consists of the Pamir mountain range, the foothills of the Himalayas.

The northern region, Leninabad Oblast, is Tajikistan's most industrialized and developed area and includes its second largest city, Khojand. Located in the Fergana Valley, it is tightly integrated with Uzbekistan which surrounds it on three sides. Dushanbe and the surrounding Hissar Valley are another important industrial center, including textile, metal working, and building materials factories, most of Tajikistan's hydroelectric capabilities, as well as the giant Tursunzade aluminum plant. Kulyab and Kurgan-Tyube, the hardest hit areas during Tajikistan's civil war, are the heart of Tajikistan's cotton production. Garm and Gorno-Badakhshan, the poorest and most isolated regions, rely on production of potatoes, fruits, such as nuts and honey, livestock and tobacco.

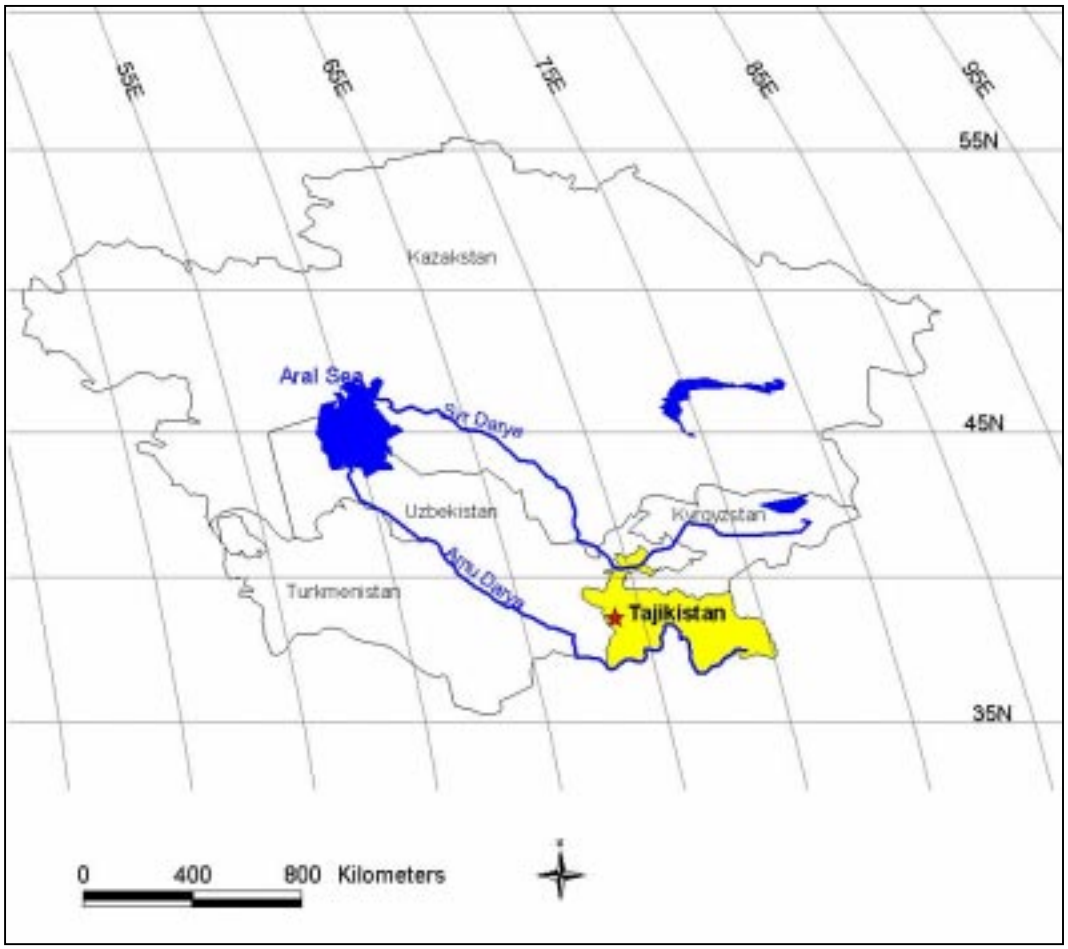

Figure 3.4: Location of Tajikistan.

Approximately 70% of the population lives in rural areas, making Tajikistan the least urban of the former Soviet republics. Tajikistan has a population of almost 6 million people. The official language is Tajik, a dialect of Persian. The ethnicity of Tajikistan is shown in Table 3.4. It should be noted that the number of Russians since 1989 have decreased by 5% (Roy, 1997).

Table 3.4: Ethnic Groups in Tajikistan

Tajiks	67 %
Uzbeks	23 %
Russians	2.5 %
Others	7.5 %

History

The Tajik Autonomous Soviet Socialist Republic was founded in November 1924 as part of the Uzbek Soviet Socialist Republic. Its borders, however, included only one third of the Tajiks living in the region. Thus Tajikistan's borders were marked artificially and did not coincide with ethnographical realities (Niyazi, 166). Tajikistan became an independent country in September 1991.

Power was retained by the Communist Party until unrest between the Islamic fundamentalists and the anti-Communists irrupted in 1992. Although the 1992 civil war, which was caused by regional economic and political differences, largely subsided by March 1993, there continues to be sporadic fighting along the Tajik border with Afghanistan between remnants of the Tajik opposition and Russian border guard forces. Although the northern region of Leninabad, the site of the majority of Western business focus in Tajikistan, had been immune from the fighting, 1996 saw the first incidents of political demonstrations and protests in the region against the government.

The government of President Emomali Rakhmonov is dominated by Tajiks from the southern Kulyab region who were victorious in the 1992-93 civil war. The November 1994 Presidential election, while peacefully conducted, was

marred by fraud and intimidation, as were the February 1995 parliamentary elections. Tajikistan also adopted a new constitution in November 1994, which while not a perfect document, is still judged to be a significant improvement over the Soviet-era version.

Russia and Tajikistan's fellow Central Asian neighbors--Kazakstan, Kyrgyzstan, and Uzbekistan--have been concerned about drug and gun running across the borders as well as Islamic fundamentalism, and have mostly supported Tajikistan's secular regime. Russia has been concerned to safeguard the 90,000 ethnic Russian's still residing in Tajikistan, and Uzbekistan to safeguard the 1.5 million ethnic Uzbeks residing there. Discrimination against ethnic Russians in Tajikistan has increased and fuels a continuing exodus of Russians from Tajikistan. The only political violence in Dushanbe has been a number of killings of ethnic Russians, usually soldiers, which has been of little comfort to Russian civilians.

Tajikistan's neighbors in the region, in particular Uzbekistan and the Russian Federation, maintain great influence over the course of internal Tajik politics through the presence of armed forces (the largely Russian CIS peacekeeping forces), supply of economic credits and humanitarian assistance, and the ability to control virtually all access to Tajikistan. Due to the geography of the region and the whims of Soviet planners, Tajikistan is largely at the mercy of Uzbekistan for all overland and rail transport. Tajikistan has moved to reduce its energy dependency on Uzbekistan by signing a tripartite agreement on trade, economic and cultural relations with Turkmenistan and Iran. Turkmenistan

provides Tajikistan with reduced cost fuel and natural gas as part of the agreement.

Economic Needs

The economy of Tajikistan in the post-Soviet period was characterized by a sharp decline in production. The main industrial and economic relations with Russia were broken. The civil war has inflicted much damage on the infrastructure and greatly affected human resources. The declines in production, which started in 1989, became more obvious after the breakdown of the Soviet Union. By 1992, the total volume of the national income (net material product) was 63.4% of what it had been in 1985. Although the civil war, unfavorable weather, and floods during the last three years aggravated the decline of production, the main cause was the cessation of incoming goods and equipment, i.e., the loss of transfers with the former Soviet republics.

Industry comprises 60% and agriculture 15.4% of the economy. The decline in productivity in these major sectors has led to the general decline of the economy of Tajikistan. In 1993, industrial production per capita was 44.9% less than in 1985, and agricultural production was 46.9% less. Before the breakdown of the Soviet Union, industrial capacity was 70 to 95% of production. At present it is less than 30%. Many major factories such as the Refrigerator Production Plant, the Tajik Textile Plant, and the Khojand Silk Plant, are closed. The declining production has made Tajikistan become the least developed member of the CIS. Along with external factors, internal situations have contributed to the decline in production. These include political instability, weak control of the economy, lack

of labor resources for industry as people switch to other occupations, absence of small and medium-sized enterprises involved in the production of goods and services, and increase of criminality due to the presence of weapons and ammunition among the population.

The industry of Tajikistan operates on imported raw materials and equipment. The equipment for agriculture, construction, transport and many other sectors was imported from CIS countries. With the economic links with the republics of the former USSR broken, Tajikistan now faces great difficulties in securing supplies of raw materials, consumer goods and food items. Negative consequences of the breakdown were intensified due to the geography of the country. Tajikistan is a mountainous country, the majority of its area is not densely populated, and transport and communication systems with other countries and regions are poorly developed.

As economic relations disintegrated, barter trade replaced the normal exchange of goods. Since Tajikistan has only limited resources for barter trade, the country remains dependent on the sister republics of the former Soviet Union. However, after independence some dramatic changes took place in the trade relations of Tajikistan. Trade increased with developed countries and declined with CIS and developing countries. Currently, more than 70% of the exports of Tajikistan are bound for Belgium, the Netherlands, USA and Switzerland. Unprocessed aluminum constitutes 73% and cotton 25% of export (UNHDP, 1997).

Social Needs

The civil war that ravaged Tajikistan soon after Independence was a tragedy of major proportions. Like other states that emerged from the former Soviet Union, Tajikistan was poorly prepared for the difficult tasks of nation building, particularly that of establishing a universal sense of national pride and identity. In a society that is as ethnically diverse as Tajikistan's, it would have been difficult under the best conditions. Before Tajikistan could create a country and its identity, however, the civil war pitted Tajik against Tajik in a violent conflict of two opposing views of the future of the new nation - religious exclusivism versus secular pluralism. A nation that should have emerged with pride and hope in the future was scarred by hatred, death, fear and uncertainty. It is the pride of Tajikistan that the majority of its population - of every ethnic group, clan and religious or political outlook - is striving toward reconciliation and a common pursuit of a stable, democratic society. The civil war had a significant impact on the national character, which is reflected in demographics, social relations and the political process and aspirations of the Republic.

Nearly 1 million people, or one of every six Tajiks, were displaced by the war. More than 250,000 persons fled the country entirely, and nearly another 700,000 persons were internally displaced. Khatlon Oblast alone, where one of every four persons was uprooted, accounted for at least 50% of the displaced. In some cases, the entire population of a village was forced to flee.

In order to ensure the safe return of refugees and the internally displaced persons, the "Law on Refugees" was adopted in 1993 and the Central Board for

Refugees and Forced Migrants was established within the Ministry of Labour and Employment. International organizations such as the United Nations High Commissioner for Refugees, the International Federation of Red Cross and Red Crescent (IFRC), the International Organization for Migration (IOM) and others have been instrumental in assisting the safe repatriation and resettlement of refugees. As a result of these combined efforts, by October 1995, 97% of the internally displaced persons and 64% of the refugees who fled to Afghanistan had been repatriated. On the other hand, only about 3,000 (1.5%) of those who fled to other CIS countries have returned. The civil war unleashed powerful emotions that continue to echo throughout society. Hatred was deliberately cultivated and led to massacres, rapes and disappearances. It has been impossible to prosecute nearly all these crimes of war, which has increased contempt for the law and feelings of impunity among the criminal element. The incidence of violent crimes, particularly those involving weapons, has steadily increased since the first outbreak of hostilities.

In Tajikistan, agricultural land is not privatized; legal ownership always resides with the State. Tajikistan's supply of agricultural land is extremely limited, and over 70% of the population is rural, depending on use of the land for their livelihoods. For these reasons the national Government wishes to ensure that land remains accessible to a broad range of the population and is not concentrated in a few hands. Under existing law, any farmer (dekhkan) head of household, male or female, who is actively engaged in agricultural production, may apply for a grant of land for private use. The size of a land grant is based on family size,

agricultural experience and the availability of land in the applicant's region. The average dekhkan farm comprises some 7 hectares. Land is distributed from sovkhozes (state farms), kolkhozes (collective farms) and the State reserves of unused land. Under this scheme, the recipient of the grant has the right to use of the land for agricultural purposes in perpetuity. He or she may bequeath that right to his/her heirs. The land, however, may not be sold nor may it be converted to non-agricultural use.

Education and literacy hold an especially honoured place in Tajik culture. At the time of the last census in 1989, 97.6% of the adult population was literate. Because of the civil war and the economic decline of the past half decade, education has suffered severely. Schools have been destroyed, damaged and closed; textbooks and other teaching materials are no longer produced; enrolment has declined; teaching staff have emigrated or departed for better and more regular paying jobs. Perhaps even more tragic is that many of those who are well educated are discovering that much of what they have learned is irrelevant to the new world that now confronts them.

While the average population density for all of Tajikistan is only 40.5 persons per square kilometer, for the total area actually populated the average rises to 193 persons per square kilometer. In the heavily populated Hissar, Fergana and Vakhsh valleys, there are 300 to 400 persons per square kilometer, and in the cities of Dushanbe, Khujand and Kurgan-Tyube, 900 to 1,100 persons per square kilometer. Along with the concentration of population, virtually all

industrial and agricultural activity is confined to the same limited territory. The environmental impact of such concentration has been significant.

Prior to 1992, the Government did not collect statistics on unemployment. Officially, there was no definition of unemployment and, as a consequence, there were no unemployed. In 1992, the Ministry of Labour and Employment began to register persons as unemployed according to a newly established definition. To be registered as an unemployed person, an individual must first register in person at an Employment Centre at their place of residence. They must also demonstrate that they are actively seeking employment by making at least two visits per month to the Employment Centre. Persons who fail to register are never counted among the officially unemployed, and those who fail to report as required are removed from the unemployment rolls after six months. Since the establishment of a system for registering the unemployed, the numbers so registered have increased each year. Some 10,900 persons were registered at the end of 1992; 21,600 at the end of 1993; 32,100 at the end of 1994; and 30,500 on 1 November 1995.

A disproportionate number of the officially unemployed are women and young people, as women comprise 45.9% of the total and 51% are youth between the ages of 16 and 29 years. Over 60% of all women counted as unemployed are persons without a profession or who have never previously held a job in the formal economy. More than 50% of all youth between the ages of 16 and 29 registered as unemployed are recent secondary school graduates who have just entered the job market. Calculation of a rate of unemployment depends on the number used as a baseline. The officially unemployed as of 1 November 1995

represented 1.1% of the officially defined labour resources but 1.6% of the actual labour pool. These numbers, however, represent only a minor part of the crisis of unemployment in the country.

Even by the most modest calculation, 513,500 persons presumed to be in the active labour pool remain unaccounted for in the official statistics for the employed and the unemployed. Even subtracting from this number the 300,000 persons estimated by the Ministry of Labour and Employment to be active in private enterprise and the informal sector, an additional 11.6 % of the labour pool are not considered to have employment.

"Hidden" unemployment is also known to exist. According to officials at the Ministry of Labour and Employment, the number of persons on unpaid leave increased 80% during the first nine months of 1995 compared to the previous year to 126,100 persons. Another 13,100 persons not recorded as unemployed were estimated to be working half time at most. Taken together this represents another 132,650 persons, or 7.2% of the labour pool, not working or actually, if not formally, unemployed.

Dependence on Aral Sea Basin

Currently 6 million Tajiks live in 143,000 square kilometers of the Aral Sea basin. Only 5% of the GDP is from agriculture, while 45% of all employment is in the agriculture business. The ICWC allocates almost 10 cubic kilometers of water from the Syr Darya and Amy Darya to Tajikistan, which consumes 13 cubic kilometers per year.

Tajikistan is the world's third largest producer of hydroelectric power after the U.S. and Russia. Hydroelectric generation accounts for 76% of total energy output in the country and almost 80% of the GDP. Energy consumption per capita is among the lowest in the NIS. An estimated 3.8 billion kWh of electricity was exported to other Central Asian countries in 1996, generating approximately $177 million in export earnings. The primary consumer was Uzbekistan, which consumed 3.4 billion kwh at a cost of nearly $170 million. Tajikistan is also an importer of electricity and in 1996 imported electricity worth $135 million, which amounted to almost 3 billion kwh, the bulk of which came from Uzbekistan (BISNIS, 1997).

The hydroelectric power station at Nurek is one of the largest in the world. The earthfilled Nurek dam, completed in 1980, is 300 meters tall (NHDP, 1997). The construction of the Rogun dam, a legacy of Soviet gigantism, has been discontinued and destroyed. Rogun was designed to have a capacity of 3,600 megawatts, which would have produced an average annual output of 13.3 billion kilowatt hours (BISNIS, 1997).

Availability of Resources

Tajikistan has substantial natural resources including gold, silver, coal, rock, salt, lead, zinc, antimony, mercury, tin, and tungsten. Many parts of the country have a long history of manufacturing and there are numerous opportunities to develop interesting businesses in a number of sectors aside from

mining, such as cotton, textiles, agribusiness, aluminum industry and eco-tourism (ERBD).

The agricultural sector is the major employer with 45% of the work force, and the most important economic activity in Tajikistan. Agricultural production makes a significant contribution to the balance of payments. Agriculture and agribusiness have helped lead the way towards economic recovery for the country since independence. Agriculture is more mechanized in Tajikistan than in neighboring countries although the country now faces shortages of spare parts and adequate maintenance. Although the agricultural sector is one of the most modernized in the NIS, total output has been declining sharply during the last five years. Cotton yields, for example, are suffering from a lack of fertilizers, pesticides and herbicides. The main crop production areas lie in the irrigated valleys of the tributaries of the Amu Darya and Syr Darya. About 720,000 hectares of land are under cultivation, mainly in the hands of state and collective farms. Cotton, which is the major cash crop accounting for about two thirds of the gross production value of the agriculture sector, takes up 35% of the cultivated area. There are uncomfirmed reports that the government intends to permit forward sales of cotton for the first time. The state cotton procurement agency, Glavkhlopoprom, has indicated that some of the cotton should be sold from foreign shipment points like Riga, Latvia, and that letters of credit should be used rather than pre-payment terms. The introduction of forward trading would serve to boost foreign confidence in Tajik cotton (BISNIS, 1997).

The 1996/97 cotton harvest of approximately 315,000 tons fell well below 1995's poor year of 415,000 tons, due to inadequate inputs, reduced acreage and poor weather. Productivity also dropped in terms of kilograms per hectare. A total of 12,000 tons of cotton was slated for use by the domestic cotton processing industry in 1995. In 1996, a total of 95,000 tons of cotton, with an estimated value of $146 million, was exported to more than 18 countries. Tajik cotton growers remain committed to the government purchasing and export agency, Glavkhlopkoprom, despite the fact that it has been paying a low rate per ton of cotton fiber. The heavy commitment to Glavkhlopkoprom means that the presidential decrees freeing cotton from the state order system haven't really been able to operate to the degree anticipated. The situation is not helped by the fact that the cotton gins remain in Glavkhlopkoprom's hands, minimizing potential competition for the farmers' crop. The gins are supposed to be in the process of privatization, which will help, but a cotton exchange is what is really needed to get buyers and sellers together in a competitive situation (BISNIS, 1997).

Tajikistan produces about 2,000 barrels of oil per day. Therefore, it must import almost all oil and petroleum products from states of the former Soviet Union. Tajikistan has estimated natural gas reserves of 1 trillion cubic feet, but gas production was minimal in 1993. Tajikistan thus relies heavily on imports of natural gas from neighboring Uzbekistan and Turkmenistan. In June 1994, Uzbekistan reduced natural gas transmissions to Tajikistan by 25% for failure to pay an estimated $46 million in outstanding gas bills. The Tajik government responded by immediately reducing gas supplies to municipal consumers. The

Pamir mountains which divide Tajikistan create ample rivers which could be used in producing hydroelectric energy. In an attempt to develop this energy source, Tajikistan has borrowed 80 billion rubles from Moscow. The terms of the loan require that Tajikistan pledge 50% of the shares of the Nurek hydroelectric power station to Russia.

Underneath Tajikistan's ever-present mountains lie a wide array of natural resources, many of which have not yet been exploited because of their geographical location or geological depth. For its size, Tajikistan is relatively blessed with silver and gold deposits. Total silver ore deposits are estimated at 60,000 tons and the largest, in Bolshoi Kanemansur, is around 38,000 tons. There are more than 30 known gold deposits, of which only a few have been prospected. Several potentially important coal deposits have been identified but have not yet been exploited. Many of the mineral deposits are suitable for relatively inexpensive open-pit mining, but they are found in mountainous regions where extreme weather conditions prevail and transportation routes are difficult or non-existent (BISNIS, 1997).

KYRGYZSTAN

Introduction to Kyrgyzstan

Geography

The Kyrgyz Republic is a mountainous country. About 94% of its territory is situated at least 1,000 meters above sea level and 41% of its territory is at least 3,000 meters above sea level (Figure 3.5). The average height above sea level is 2,750 m, the maximum height 7,439 meters, the minimum height 401 meters (the territory of Lailaik district). The wide range of absolute heights, complex relief, protracted geologic development of the country and other factors result in the variety of natural conditions and the richness of natural resources. All natural zones, characteristic of Northern Hemisphere, except for tropical zone, can be encountered on the territory of the Republic. Kyrgyzsatan's population of January 1, 1996 was 4.49 million people, which included 70 different nationalities. Table 3.5 shows the largest ethnic groups which make up Kyrgyzstan (Roy, 1997).

The climate ranges from extreme continental to nearly maritime due to considerable relief raggedness and a large lake, Issyk-Kul. Summer is dry and hot. Winter is rather cold, especially in the mountains and intermountain basins. The maximum air temperature is $+44^{o}$C, the minimum -54^{o}C (meteorological station Ak-Sai). The largest amounts of precipitation per year, 1,090 mm, fall at the

western slope of the Fergana ridge and the least, 144 mm, at the western extremity of Issyk-Kul basin (Kyrgyzstan, 1997).

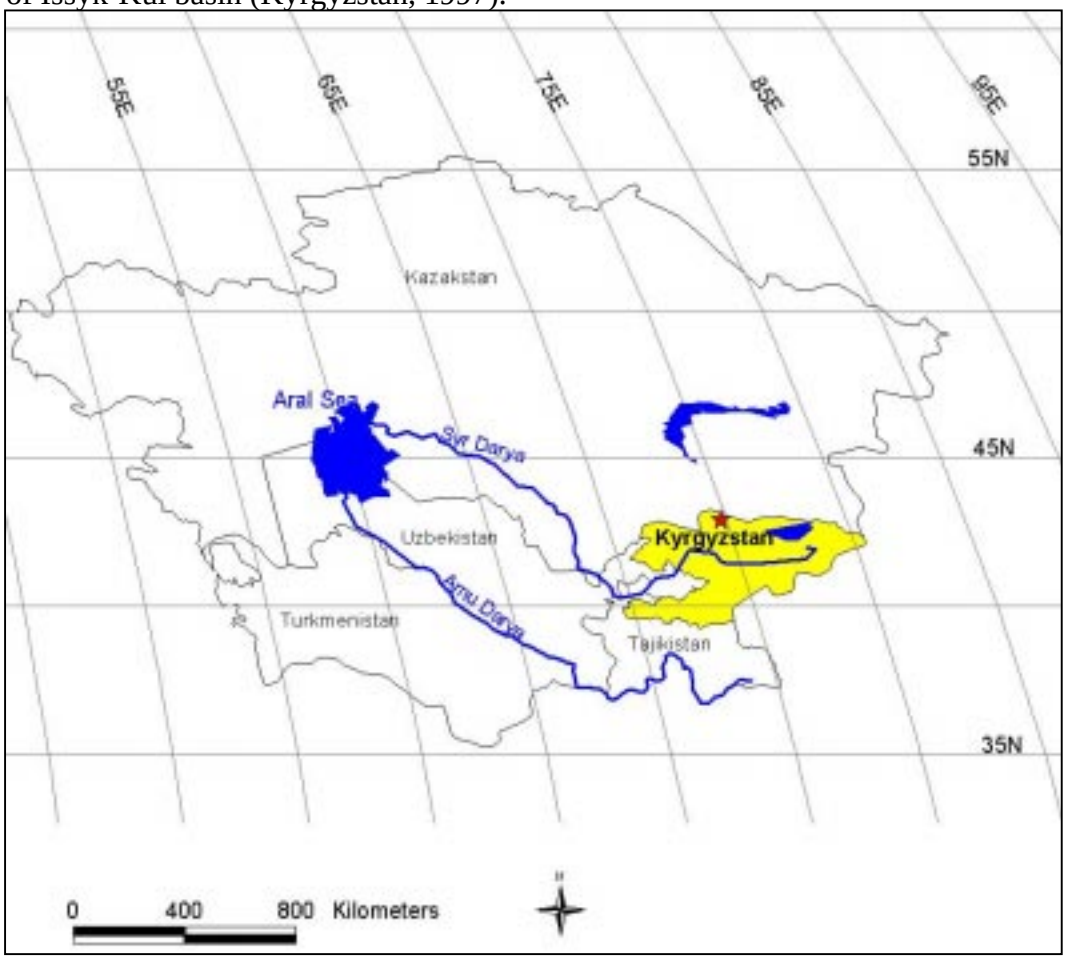

Figure 3.5: Location of Kyrgyzstan.

Table 3. 5: Ethnic Groups in Kyrgyzstan.

Kyrgyz	59 %
Russian	18 %
Ukranian	14 %
Others: Uzbek. Ukanian, Tatars	9 %

History

The Kyrgyz area was annexed to Russia in 1864, and became the Kara-Kyrgyz autonomous area in 1917. The area was reorganized in 1926 and became a constituent republic of the USSR in 1936 (Infopedia, 1996). The Republic of Kyrgyzstan was proclaimed by the Declaration of Sovereignty on August 31, 1991. On May 5, 1993, the Constitution the Main Law declared a new name of the state - the Kyrgyz Republic. The capital of the country is Bishkek, founded in 1878 and named Pishpek, since 1926 it has been called Frunze. On February 5, 1991 it was renamed Bishkek.

According to the Constitution of the country, the Kyrgyz Republic is a unitary, democratic, secular state, the priority legal norms of which are universal human values. The Main Law guarantees democratic rights to country citizens: the freedom of religion, ecclesiastical and cult freedom, an open expression of thoughts, ideas and opinions, the freedom of the press, the right for unrestricted travelling and living everywhere, the right for property, the privacy of correspondence, the freedom of meetings and demonstrations. As well, the main law guarantees the right for inviolability of dwelling, the freedom of the private life, and universal equality before the Law. According to the form of the government, Kyrgyzstan is a democratic republic with a presidential form of governing, based on norms of a law-abiding state.

Little has changed since independence in terms of governing structures, the way decisions are made, or the people in power. State structures remain

substantially the way they were ten years ago. A full-time Parliament was elected in February 1995, but the way in which such a parliament will function has yet to be worked out. An independent court system is in the process of being established; yet the average citizen feels little difference in terms of personal empowerment. Furthermore, given the importance of establishing the rule of law for democratic state-building, Kyrgyzstan has a long way to go in reforming its courts and establishing an independent judiciary, along with a strong and self-governing legal profession. Nevertheless, the People's Assembly of Kyrgyzstan, formed in January 1994, plays a special role in ensuring inter-ethnic and civil harmony.

However, the transitional process of bringing about the intended market-based regulation mechanisms has been accompanied by mistakes. It could hardly have been otherwise, as the attempted transition has been carried out at the same time as a struggle to bring the country out of an acute and profound economic crisis and to alleviate its painful consequences in people's lives. Indeed this period of transition from communist to market economy has been without precedent in history. One must also consider that people in general are ignorant of market principles, and the appropriate specialists for the new system do not exist in sufficient numbers. Soviet executives still predominate in administrative structures, and these have not only shown inability to move towards reform, they also hindered it, as well as pursuing their own selfish interests to get rich while hiding behind the notion of "economic freedom."

Thus at times privatization yielded to a kind of privatizing introduction of economic regulation and gave way to dismantling of all regulation; and an effective taxation system was seemingly destroyed before it was created. One serious and urgent task now is to generalize the lessons of the reform experience from 1991 to 1995, take account of positive experiences in other countries, and make corrections to both the concept and programme of reform for 1996 to the year 2000. The state should actively assist in developing economic freedom. The entire system of market mechanisms in the transition period should be given a thorough going-over.

Economic Needs

The people's standard of living is continuing to drop correspondingly, though again not as steeply as in 1994, a fact which is certainly related to the positive results achieved in restraining economic decline and stabilizing public finances. The level of inflation in 1995, at 32%, or 2.5% per month, was the lowest it has been since the start of the economic reform, and was one of the lowest in the CIS. At the same time, GNP per capita has also declined from $1160 to $610 in 1994.

The democratic processes now under way in the Kyrgyz Republic have become irreversible, a fact which was shown by the recent parliamentary and presidential elections. These constituted a firm political and social guarantee that human development resources will be under the constant attention of the government and that actions undertaken for human development will be under the control of all people. However, the challenge of ensuring inter-ethnic and civil

harmony still remains in light of a sharp decline in the country's economic output, high unemployment and a collapse in the social safety net that people had grown accustomed to during the Soviet era. Ethnic tensions have heightened as non-Kyrgyz feel the pinch of the government's efforts at affirmative action. At the same time economic deterioration and the shrinking pool of jobs and government resources further exacerbated tensions between groups who see themselves in competition with one another. Rapidly declining economic conditions and a virtual cessation of state-sponsored social services contributed to the sharp contrast Kyrgyz citizens see between their lives now in comparison with their experience under the Soviet system.

National revenue produced in 1995 was 47.2% of the 1990 level, on a par with the former Kyrgyz SSR's output in 1979. In other words, the five year period from 1991 to 1995 witnessed an economic recoil of 25 years. A minimum of 20 more years may be required to redress this, during which the country may still face an economic crisis.

Efforts to analyze the shadow economy and to estimate its value have been made. In 1994, the National Statistical Committee estimated that the shadow economy amounted to 780 million Som (approximately US$ 52 million) or 6.5% of GDP. Estimates have also been made to analyze undeclared production, which in 1994 was valued at 2 to 2.5 billion Som (approximately US$ 167million), of which bootleg liquor production alone generated around 1 billion Som (approximately US$ 67 million). In addition revenue losses to the state, through for instance the failure to register businesses and pay taxes, suggest that the

discrepancy between total possible revenues from all forms of economic activities and the actual amount taken in is of the order of 10 to 15 fold.

No less turnover takes place in the sphere of criminal business, which includes the drug trade, of which the moral and material damage done is every bit commensurate with the losses engendered by the development of other kinds of shadow economic activity. Another big business is prostitution, together with the direct and indirect trade in official commissions, involving a broad cross-section of managers and employees of law enforcement organs. All of the above indicates that the actual volume of the shadow economy is much larger than is thought by official agencies, and that it awaits more precise estimation. As for the material loss connected with the shadow economy, economic crime cases which were brought to court in 1995 (which were arguably only a small proportion of the total), involved in 1995 alone 475 million Som (approximately US$ 32 million), which is four times more money than all income tax revenues, three times greater than the state's annual outlay for public security and civil order, 54% of the republic's budget and 85% of total profits earned by industrial enterprises.

Overcoming the growth of the shadow economy will evidently be extraordinarily difficult. Factors working against this include the continuing stratification of society according to property ownership, the low standard of living of the majority of the population, lack of entrepreneurial background among a great many managers, and most serious of all, absence of any large-scale state actions to combat corruption, through for example the strengthening of law enforcement and improving the legislative base. Also just as important is the

problem of organizing data bases and analyzing the shadow economy in a systematic way.

Social Needs

According to the World Bank, at the end of 1993, about 45% of the population were categorized as poor and almost 30% more lived in extreme poverty. In total, roughly 75% of the republic's population are living below the poverty line. The calculations of the national Statistical Committee and the World Bank differ, but both testify to a high level of poverty. In 1993, Kyrgyzstan adopted the Minimum Consumer Budget (MCB), established by law, and which is linked to a set of 33 foods and non-food goods and services, expressed in monetary price, which would provide a person with a level of consumption accepted by society as the minimum allowable at the given stage of its development. The MCB is a flexible measure and depending on a given threshold, estimates of the population below the poverty line have varied from 71% to 92%, implying that out of a population of 4.5 million, only 477,000 people are considered to be sufficiently provided for in a material way.

This is not only the consequence of the economic crisis which has occurred since 1991, but is also a legacy of the Soviet period. Since Kyrgyzstan was traditionally one of the most backward republics of the USSR in terms of economic and social development, and living standards, it used to receive subsidies to alleviate the population's socio-economic and social difficulties. But with the disintegration of the USSR, these subsidies came to an end.

With regard to the alleviation of poverty, the UN states that poverty caused by low wages or low income can be reduced first of all through higher-paying employment, improvement of labour qualifications and various supplementary sources of legal income. Reducing poverty among the retired will depend entirely on state solutions and on owners of non-state companies who may define and allot pensions on their own account or in addition to state pensions. Also, some but not all pensioners can supplement their incomes through work. Just as serious as the problem of reducing poverty is the question of how to provide jobs to the able-bodied population. Job shortages existed even in Soviet times, but now many of the jobs no longer exist because of halted or decreased production. Among employment problems, providing jobs for young people is especially urgent. Young people without jobs swell the ranks of the unemployed and worse, the criminal world.

The transition period has given rise to at least three new types of unemployment:

1. Unemployment caused by insufficient or absent demand for the products of presently functioning enterprises, where labour supply exceeds demand due to job cuts;
2. Structural unemployment, related to a deficit of personnel of a particular profession and qualification level;
3. Frictional unemployment consisting of those who are entering the labour market for the first time, or who have lost their jobs, or who are changing jobs.

Several alarming processes are occurring today which may undermine the literacy and health of the population, the two HDI components which Kyrgyzstan previous had at fairly high levels. Firstly in the education system, the fact that not all school-age children are in school is cause for serious concern. Secondly, one of the most serious consequences of the people's sharp drop in living standards has been the growth in infectious disease rates. Prostitution is on the rise, and therefore sexually transmitted diseases. No less alarming has been the outbreak of tuberculosis and other dangerous infectious diseases.

The situation of women in the labour market has worsened. Fifty percent of the unemployed are women and 18% of these are mothers of many children. It is more difficult, and increasingly so, for women to find work than for men. The high proportion of women formerly employed in both productive and non-productive spheres has contributed to their becoming the most vulnerable group. While women in Kyrgyzstan tend to receive lower wages, have less access to employment and undergo fewer years of schooling, as shown by the corresponding male female gender gaps, women exceed men in terms of life expectancy, in population and secondary enrollment. In other areas, such as that of university enrollment, women far exceed their male counterparts (by 62%), and by over 113% in the natural and applied sciences, thus showing women's stronger participation in knowledge-based fields. On the other hand, there were 46% more of unemployed women than men.

Pollution is a major problem, particularly in urban areas. While falling industrial and agricultural production has led to reductions in raw sewage

emissions and emissions of atmospheric pollutants, the economic decline has also cut funding for environmental protection and caused the quality of waste treatment installations and garbage disposal to drop. Water pollution is increasingly serious in Bishkek as aquifers of clean water have been penetrated by surface water polluted by industrial and human waste. Vehicles are a major cause of air pollution, and coal smoke in winter further aggravates air quality. In agricultural areas, pesticides continue to deteriorate the environment. Excessive cultivation of marginal lands, and deforestation has put pressure on land and forest resources. Mining has also created large areas of waste land, with tailings and other harmful substances being left exposed to neighbouring populations. The necessity of protecting the environment was only first acknowledged in the 1980's but no environmental protection programmes have been implemented in full (UNHDP, 1997).

The republic's housing space is on the whole expanding, through not to a significant degree. It is only private housing that is experiencing growth: state, public and cooperative housing space is shrinking drastically due to lack of funding. The acute housing shortage inherited from the Soviet period has not gone away. Furthermore, the stock of buildings has continued to age and there have been no capital repairs to residential buildings and infrastructure since 1992, due also to lack of funds. Although 90 % of all urban settlements in the country have running water, electricity and telephones, the infrastructure is weak and prone to breakdowns. In fact, human settlements are mostly rather unimproved, with low quality roads and walkways, minimal landscaping and plantings and poorly

constructed outbuildings, which all together reduce the quality of the human environment.

Nevertheless, the country has been blessed with abundant water, an extensive hydroelectric network and heating infrastructure. However, during the Soviet period, and especially in its final years, the quality of construction in terms of finished buildings was very low, and materials, especially those used in finishing work and decoration, were of poor quality. Kyrgyz architects are now attempting to improve the quality of design, both aesthetically to reflect cultural traditions, as well as to be more resistant to the strains of the extreme weather conditions and earthquakes.

Under the influence of corruption, organized crime and shadow economic activities, society breeds destructive and anti-social desires which in turn work to mould a corresponding consciousness. Inattention to these problems attempts to underplay their danger, and lack of a systematic approach to fighting these phenomena can undermine the very viability of the nation. Closely linked to the loosening of moral and material controls on the poor economy and their corresponding economic and social consequences, there has been a worsening of personal safety caused by a rapid increase in crime. As the economic crisis proliferated, the very infrastructure of society has been changing. Crime has expanded both quantitatively and qualitatively, and remains largely unsolved, due to the weakness of the law enforcement agencies.

Kyrgyzstan's geographical location and transit routes place it in the centre of a region of narcotics production and consumption, which has caused acute

social problems. A flood of opium has poured into Kyrgyzstan, which is then sent onward through the CIS, and countries further abroad. The nature and scale of drug use in Kyrgyzstan itself has been both underestimated and misunderstood, and partially kept out of the realm of public information and debate, thereby worsening the problem. The explosion in crime witnessed in Kyrgyzstan has many causes, of which the most important are:

- Changes in ownership relations and the ensuing confusion and mistrust in the future, with the corresponding growth of opportunism to appropriate property and money by illegal means;
- Drastic weakening of state power in general, and of power over economic crime in particular;
- Errors in the conduct of economic reform, which contributed to a sharp decline in the population's standard of living (UNHDP, 1997).

Dependence on Aral Sea Basin

Out of 4.4 million people in Kyrgyzstan, 2.3 million Kyrgys live in the Aral Sea Basin which encompasses 127,000 square kilometers. The ICWC allocates less than 0.4 cubic kilometers per year to Kyrgyzstan, which consumes a total of 5 cubic kilometers (World Bank, 1996). More than 36% of the GDP is from agriculture, while 28% of all employment is in the agriculture business. Kyrgyzstan also operates reservoirs and dams that are used for hydroelectric power management and management of water releases for downstream countries (Kygyzstan, 1997). This production of hydroelectric power from the Syr Darya is major source of income and employment.

Availability of Resources

There are several types of minerals in production in Kyrgyzstan: antimony, coal (twelve coal mining enterprises are in operation in different regions including six open pit mines), gold (major and minor deposits and gold mining enterprises), mercury, oil and gas, uranium trudovoye complex, and quartz. Kyrgyzstan also has deposits of rare strategic metals such as cesium, yttrium and lanthanum. It has marble, granite and precious stones. Development of the Kyrgyz mining and minerals industry, particularly gold mining, is planned as a major basis for (1) strengthening the financial base for the reforms in Kyrgyzstan, (2) to build up Kyrgyz gold reserves, and (3) to create jobs.

Kyrgyzstan is known for its gold-bearing deposits - large, small, placer or bedrock, but until independence, only one deposit, the Makmalskoye, was worked. The gold went to Moscow, and mining operations were secret. The highest reported figures for production were in the range of 5,000 kg per year, but in 1992 this fell to just over 1000 kg, down from 2,000 kg in 1991. By 1995, production, mainly from Makmalskoye, was up to about 4,500 kg. Kyrgyzstan has been reported as having on deposit two tons of gold bullion in a Swiss bank (reported elsewhere as 1,634 kg with an additional 385 kg in the Kyrgyzstan National Bank). Geologists have to date prospected several new gold deposits and these, in addition to 30 deposits already explored, are planned for development.

Post-independence tenders to develop Kyrgyzstan's gold mining industry indicated that locally sourced funding and project experience were inadequate for

the very large, complex projects that were required to accelerate economic growth. Thus to develop its large mining projects, Kyrgyzstan depends on foreign investors, in particular Cameco of Canada, which is developing the Kumtor deposit. Kyrgyzstan hopes to take its gold production to 20 tons per year by 1998. In 1993, oil production was 1 million barrels per year, coal production was 2-6 tons per year and natural gas production was 55 billion cubic meters, far below the country's consumption levels (BISNIS, 1997).

Kyrgyzstan is a major producer of hydroelectric power and has enormous unexploited potential. Several potential projects are on the drawing board, but need secured export markets and project financing. Two projects, to upgrade the district power and heating plants, and second to upgrade and improve maintenance of the electric distribution system are slated for multilateral financing. These will provide opportunities for electric power exports. The agriculture sector is now the largest sector in Kyrgyzstan but is severely disorganized and under capitalized. Several donor projects will focus on improving credit to the sector and there will be opportunities for small scale operations in a variety of areas: improved seed, fertilizer, small scale farm equipment, food and textile processing equipment, improved storage, packaging. Light manufacturing has shown the fastest recovery in growth. There will be a variety of niche opportunities in light manufacturing equipment on a small and medium scale (BISNIS, 1997).

In May 1995, the European Bank for Reconstruction and Devlopment (EBRD) made a loan of 38 million US dollars to the Kyrgyz Energy Company to

finance the upgrading of the electricity transmission network in the Issyk Kul area of Kyrgyzstan (which includes the Kumtor gold mine). The project includes the construction of a new power line to ensure a reliable supply to Kumtor and improve the quality of the supply to other consumers in the region. The EBRD is also providing technical cooperation to assist in the commercialization of the Kyrgyz Energy Company. The EBRD has advanced a US$ 30 million senior loan and a US$ 10 million subordinated loan towards the development of the Kumtor gold mine. In October 1995 the EBRD approved US$ 9 million for the creation of the Kyrgyz Agribusiness Company (KAC), a private company which provides essential agricultural input, farm equipment, storage facilities and extension services. Four other major foreign investors in cooperation with local investors also contributed towards the US$ 22 million total project cost. By strengthening intermediate markets, the project will contribute to the development of the entire agribusiness chain (BISNIS, 1997).

Although it has many social problems, there are several reasons to invest in Kyrgyzstan. Kyrgyzstan has a sustained commitment to the implementation of market-oriented reform and macroeconomic stabilisation and has a politically sable environment. Kyrgyzstan has enacted about 27 bilateral agreements directly affecting trade in goods and services, and has regional economic cooperation or integration agreements with Turkey, Iran, Pakistan, Belarus, Kazakstan, Russia, Uzbekistan, and other members of the Commonwealth of Independent (ERBD, 1997).

CHAPTER SUMMARY

The five Central Asian republics have a large base of natural resources. Independently, many of the republics are lacking in some resources. This is one cause of the economic crisis striking Central Asia since the fall of the Soviet Union in 1991. These countries must now pay for previously shared resources. Figure 3.6 shows the location of mineral resources throughout Central Asia (ArcAtlas, 1997). Many of these resources are located along the Amu Darya and Syr Darya, adding to the pollution of the rivers. Figure 3.7 shows the population density of Central Asia. The highest population density is along the Amu Darya and Syr Darya also contributing to pollution.

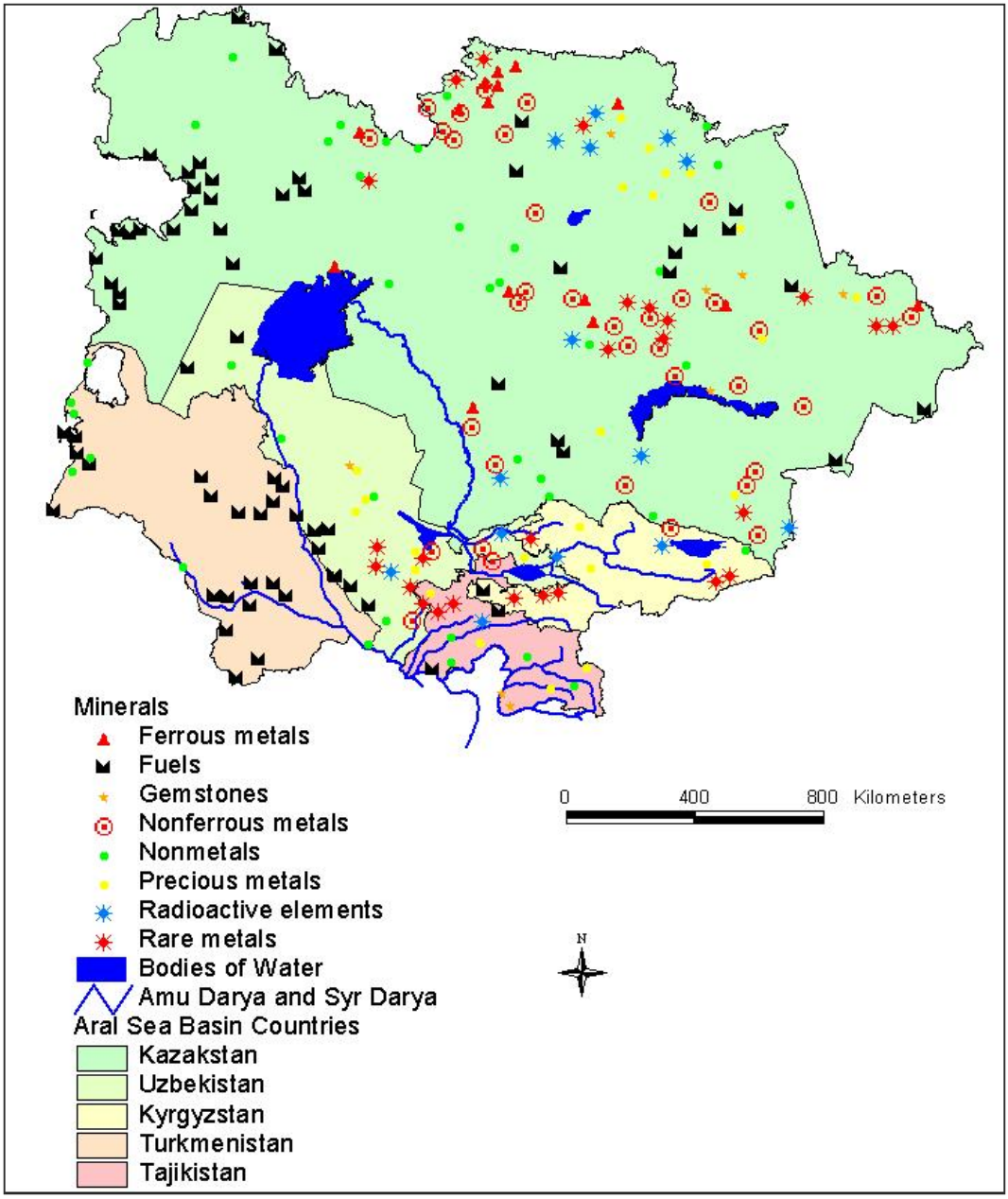

Figure 3.6: Minerals in the Aral Sea basin.

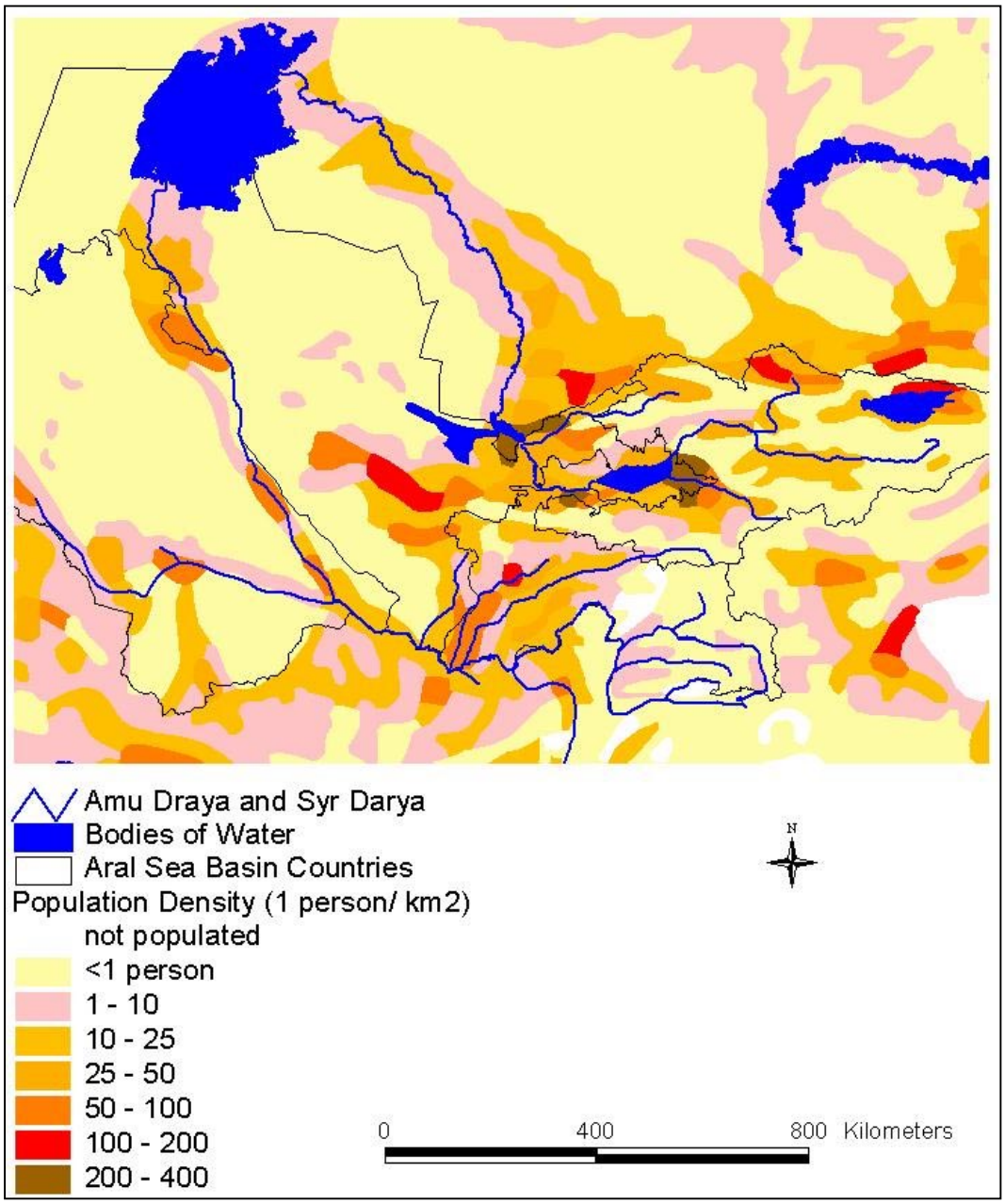

Figure 3.7: Population density in Central Asia (1 person/km^2).

Kazakstan has endured hardships since independence. Sixty four percent of the population live below the poverty line. The fall of birth rates and the increase of circulatory diseases, accidents, murder, suicide and lung cancer (partly due to Aral Sea salt in the air) has caused the absolute natural growth to decline by 43 percent. Half of all nurseries and kindergartens have been forced to close due to diminished funding, and funding for education in general has been greatly diminished. Kazakstan has great resources including 16 billion barrels of oil. Gold mining could prove to be very resourceful once the capital to develop the industry is invested. Coal-fired stations produce most of Kazakstan's electricity, and Kazakstan also imports 30 percent of the electricity requirements from neighboring countries. Ninety percent of Kazakstan's use of the Aral Sea waters is for agriculture.

Uzbekistan is the only Central Asia country to have had only a small drop (18%) of GDP since independence. Yet, 70 percent of the population lives under the poverty line. Uzbekistan relies heavily on the 4.2 million hectares of land (out of 27 million hectares) it irrigates. The increasing salinity and the high use of fertilizers has made the water available in Uzbekistan almost unusable for household purposes; this has increased the incidence of liver, kidney and nervous system diseases, especially in Karakalpakstan.

Uzbekistan does have large resources in cotton, gold, and natural gas. It's electric power is derived primarily from natural gas powered thermal plants with a smaller portion coming from coal and hydroelectric power (mostly imported from Tajikistan's use of the Amu Darya or from its own plants on the Amu Darya). Its

status of the world's fourth highest producer of cotton makes Kazakstan even more dependable on the Amu Darya.

Eighty percent of Turkmenistan is made up of the Kara Kum desert, making the Amu Darya its only source of water for the irrigation of the only 10 percent of total land suitable for agriculture. Turkmenistan also uses the Amu Darya to produce 13 billion kWh; enough for all its electricity needs, and to export 25% of it. Furthermore, Turkmenistan is the world's fourth largest producer of natural gas and it owns 64% of all Central Asian oil reserves. Turkmenistan has a strong government which has made education a priority; 99.6% of the population is literate and secondary education is increasing. Turkmenistan also differs from the other Central Asian countries, as its population has increased by 2.5% per year due to high birth rates, and migration. Women enjoy a particularly high standing both economically and socially; 36% of managers, 18% of Parliament, and 41% of blue and white collar workers are women.

Tajikistan faces major difficulties; discrimination towards women and ethnic Russians, drug and gun cartels, high unemployment of women and youth, Islamic fundamentalists, and the dependence on Uzbekistan for all overland and rail transport. As the world's third largest producer of hydroelectric power, Tajikistan is extremely dependent on the Amu Darya water to produce 76% of its energy requirements and $177 million in exports. Furthermore, Tajikistan has almost no oil and natural gas resources making it completely dependent on hydropower for electricity and export revenues. These export revenues are

extremely important since Tajikistan has many times failed to pay Uzbekistan for its import of natural gas.

Kyrgyzstan is also dependent on the Syr Darya; it owns and operates the Toktogul Reservoir made for hydropower and for water releases. These water releases enable Kyrgyzstan to trade with Uzbekistan and Kazakstan for natural gas and oil. Kyrgyzstan has left much of the Syr Darya cascades and gold mines undeveloped primarily because of its lack of investment capital. Kyrgyzstan has many social problems. Seventy five percent of the population lives under the poverty line. Many school age children are not in school. The drop in living standards has increased infectious diseases such as sexually transmitted diseases and tuberculosis. Women are finding it harder and harder to get work and women now make up more then fifty percent of the unemployed in Kyrgyzstan (even though women's enrollment in university and applied science programs is higher than men's).

Chapter 4: Sharing the Aral Sea Basin Waters

INTRODUCTION

The United Nations "recognizes that water has an economic value in all its competing uses and should be recognized as an economic good" (UN, 1997). Managing water as an economic good is an important way of achieving efficient and equitable use and of encouraging the conservation and protection of water resources. It is therefore important for the five nations of the Aral Sea basin to work together to achieve an equitable use of the basin's waters in order to achieve economic security and to protect the Aral Sea to the fullest extent. The remaining topics to be addressed in this thesis according to the Helsinki Rules are the past utilization of the waters, the conservation, protection, development and economy of the uses of the water resources and the cost taken to realize that affect, and the availability of alternatives to planned or existing uses.

EFFECTS TO THE ARAL SEA ENVIRONMENT

About 97 percent of the annual water resources of the Aral Sea basin are directly lost to field evaporation, transpiration or absorbed by plants, animals, or to transmission problems such as pipe leaks, reservoir evaporation and discharges of return flows into salt lakes (Klotzli, 1994). Another problem is due to the increase of the irrigated farming with a 100% increase in production (World Bank, 1996). Figure 4.1 shows the different landuses of the Aral Sea basin (ArcAtlas, 1997). Most of the area is arable and therefore very suitable for agriculture. In 1988, the water usage in the Aral Sea basin for all purposes was

125% of the annual available water resources. This value was possible because of the return flows used downstream (Klotzli, 1994). As the Central Asian countries develop more stable economies, the increase in industry rather than agriculture will help ease the demand of Aral Sea waters.

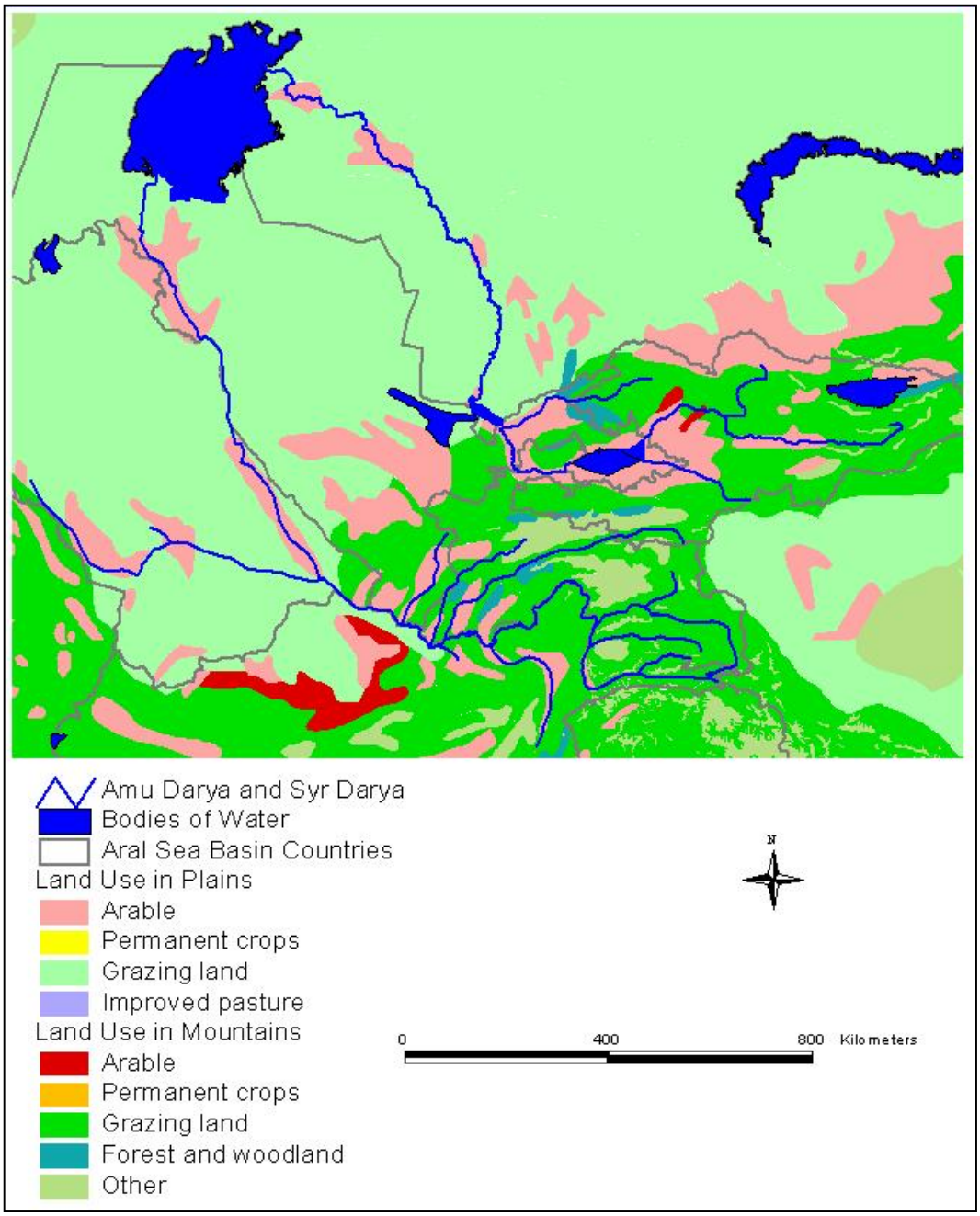

Figure 4.1: Landuse in the Aral Sea basin (ArcAtlas, 1997).

Environmental changes of the Aral Sea basin and adjacent territories have taken place over the last 20 years. Desiccation of the Aral Sea has resulted in variations of some climatic and meteorological indices. The climate has become more continental. The albedo of areas formerly occupied by the Aral Sea have increased seven times, producing a more than threefold increase in the reflected solar radiation the Aral Sea. Spring has arrives seven days later, while the autumn season arrives 12 to 13 days later (UNEP, 1991).

Important consequences of water balance variations in the Aral Sea basin include the following (UNEP, 1991):

1. A rise of the ground water table on and near irrigated massifs with insufficient drainage as well as near canals and the main drains, resulting in salinization and waterlogging of soils, and subsidence of surface structures;
2. A siginificant increase in the discharge of high mineral content drainage water to rivers. The pesticide and mineral fertilizer content of these waters has lead to deterioration of river water quality;
3. The formation of new discharge lakes in closed depressions, to which drainage water from irrigated massifs is discharged and lost by evaporation and infiltration;
4. Decreased river water inflow to the lower parts of the Amu Darya and Syr Darya deltas which leads to the disappearance of many delta lakes
5. A decrease in the river water inflow and decrease in water level in the Aral Sea have caused a decrease in a area and volume, an increase in

salinity, disruption of the sea ecosystems, and formation of new land area.

It has been determined, by the UNEP, that the Aral Sea cannot be saved to its prior grandeur. Restoring the sea would mean stopping many hydrotechnical systems and irrigation in the basin. It is important, however, to prevent the further decline of the Aral Sea so as to not further harm the surrounding population and economy. The first priorities are to reduce the runoff of saline drainage waters into the rivers, and to improve the natural and social environment in the Aral Sea basin (Murzayev, 1992). Furthermore, irrigation techniques in the Aral Sea basin need to be improved so that 40% of water isn't lost to evaporation and drainage.

PAST AND PRESENT UTILIZATION

Before the fall of the Soviet Union, the large storage reservoirs of the Aral Sea basin functioned for irrigation and hydropower purposes. However, irrigation use had the principal importance and therefore the reservoirs stored water to be released during the summer vegetation season. Since the fall of the Soviet Union in 1991, the upstream States of Kyrgyzstan and Tajikistan have been in need of electricity especially during the cold winter months. As discussed in Chapter 3, this need of hydropower is due to the lack of developed oil, gas, coal and other energy producing resources in Tajikistan and Kyrgyzstan. The downstream States, Turkmenistan, Uzbekistan, Kazakstan, however, are in need of the water during the summer months for agricultural purposes, thus leading to the conflict over

water rights. The downstream States have therefore been exchanging their natural gas and coal in the winter for water from the upstream states during the summer.

The Aral Sea Basin has more than 80 storage reservoirs, each having a capacity over 10 million cubic meters. The Syr Darya reservoirs have a total capacity of 0.73 of the mean annual flow and are therefore large enough to provide year to year stabilization of river flows, while the Amu Darya reservoirs with only 0.21 total capacity of the mean annual flow, provide much less control.

The waters in 1994 were measured by the World Bank (1996), shown in Table 4.1. The World Bank also calculated projected outflows for the year 2010 (Table 4.2). The continued decrease of the inflow to the Aral Sea by the year 2010 will deteriorate the economy and environment even further. In the next 16 years, the inflow to the Aral Sea will decrease another 8% from 182 km^3 to 168 km^3, thereby decreasing the Aral Sea inflow another 13 km^3.

Table 4.1: Inflow to the Aral Sea basin in 1994 (km^3/yr).

	Amu Darya	Syr Darya	Total Aral Sea Basin
Surface water inflow	80.3	41.2	121.5
Groundwater recharge	6.2	7.8	14.0
Return water	31.3	14.6	45.9
Inter-basin transfer	-	1.0	1.0
Total (km3)	117.8	64.6	182.4
Diversion to agriculture	65.6	36.0	101.6
Aral Sea inflow	52.1	28.5	80.6

Table 4.2: Projected Inflow to the Aral Sea Basin in 2010 (km^3/yr).

	Total Aral Sea Basin
Surface water inflow	115.6
Groundwater recharge	18.0
Return water	32.9
Inter-basin transfer	1.0
Total (km3)	167.5
Diversion to Agriculture	100.7
Aral Sea inflow	67.5

Table 4.3 lists the measured (1994) and forecasted (2010) uses of the waters of the Aral Sea basin. By comparing Table 4.3 to Table 4.1 , it is evident that in 1994, which was an extremely dry year, there was a deficit of 0.5 cubic kilometers, and the calculated deficit for 2010 is 23 cubic kilometers. One should note that this deficit is caused mostly by the downstream countries: Tajikistan and Kyrgyzstan together produce about 75% of the water, while only consuming 10%, and Afganistan contributes about 8% of the inflow but has not been a party to the Aral Sea Programs because of its political instability.

Table 4.3: Measures (1994) and estimated (2010) uses of the Aral Sea basin waters (km^3/yr).

	Amu Darya, 1994	Syr Darya, 1994	Total Aral Sea Basin, 1994	Total Aral Sea Basin, 2010
Losses from river channels	7.0	3.2	10.2	10.2
Surface flow losses due to groundwater withdrawal	4.2	3.3	7.5	10.6
Unused discharge of vertical drainage	1.6	1.0	2.6	4.0
Transfer to other basins	1.0	-	1.0	1.0
Withdrawals by all economic sectors	66.0	45.7	111.7	131.6
Diversion of return waters to Aral Sea and natural depressions	13.6	2.8	16.4	10.0
Water withdrawal by Afganistan	2.0	-	2.0	5.0
Discharge into Aral Sea by main streams	21.7	9.8	31.5	19.0
Total uses (km3)	117.1	65.8	182.9	191.2

Water demands in Central Asia are dominated by the needs of agriculture, accounting for 92 percent of the total use. Industrial production requires 2 percent of the water demand, municipal use accounts for 3 percent, and the remaining 3% are required for rural water supply, fisheries and other miscellaneous uses (Anderson, 1997). Table 4.4 shows the shares of water in each sector for each country in Central Asia. Uzbekistan uses over half of the Aral Sea basin waters, while Kyrgyzstan and Kazakstan use less than 10%.

Table 4.4: Uses of water in the Aral Sea basin, km^3/yr (World Bank, 1996).

	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan	Kazakstan
Agricultural Water Use	4.9	10.3	23.3	53.4	9.7
Irrigation (%)	96.7	86.0	97.7	91.2	89.0
Rural Water Supply(%)	1.6	5.2	0.2	1.6	1.2
Industrial Use	0.1	0.3	0.4	1.1	0.2
Other Uses	0.2	3.0	0.5	5.3	1.0
Total Water Use (km3)	5.1	13.3	23.8	58.6	10.9

Agricultural water demands have mainly increased since 1950 because of the massive extension of the irrigation area. Transmission systems have many "built-on-sand canals" which account for a large portion of water losses, and irrigation system efficiencies are very low throughout Central Asia. Cotton plants (37% of the agricultural production) necessitate about 0.8 to 1.0 meters per year of water in Central Asia. However, other regions in the world have been able to produce 6 to 7 times more cotton with the same amount of water by using water-saving techniques (Klotzli, 1991).

Of the 155 million hectares of land resources in the Aral Sea Basin, only 33 million are considered suitable for irrigation while about 7.9 million hectares are actually irrigated. Rain-fed agriculture, which is mostly pasture and hay, occupies about 54 million hectares. It is an important goal to increase the production of the rain-fed areas. Cotton, whose production share decreased by 8% from 1990 to 1994 to 37%, still dominates irrigated agriculture. Meanwhile, the cereals have increased to 26% and fodder crops have decreased to 23 %. The high

costs of gasoline and chemical fertilizers, and disrupted markets have caused the levels of both yields and production of major corps such as cotton, cereal, maize, in irrigated farming to decrease by 5% since 1990 to 40% (UNEP, 1991).

Hydropower produces 35% of electricity in Central Asia, thanks to natural conditions such as waterfalls. Industrial water demand in the Syr Darya is 12% of the total water demand, while it is only 6% in the Amu Darya.

Since irrigated agriculture makes up 92% of the basin water use, it is important to understand which countries use the most water for agricultural purposes. The pie chart below illustrates the agricultural use of water in the Aral Sea Basin (see also Table 4.4). Since irrigation uses consume almost 92% of the Aral Sea basin waters, the shares of water for irrigation are a good indicator of which country consumes the most. As can be seen, Uzebekistan, whose Aral Sea Basin population is over 22 million people, uses over half the water.

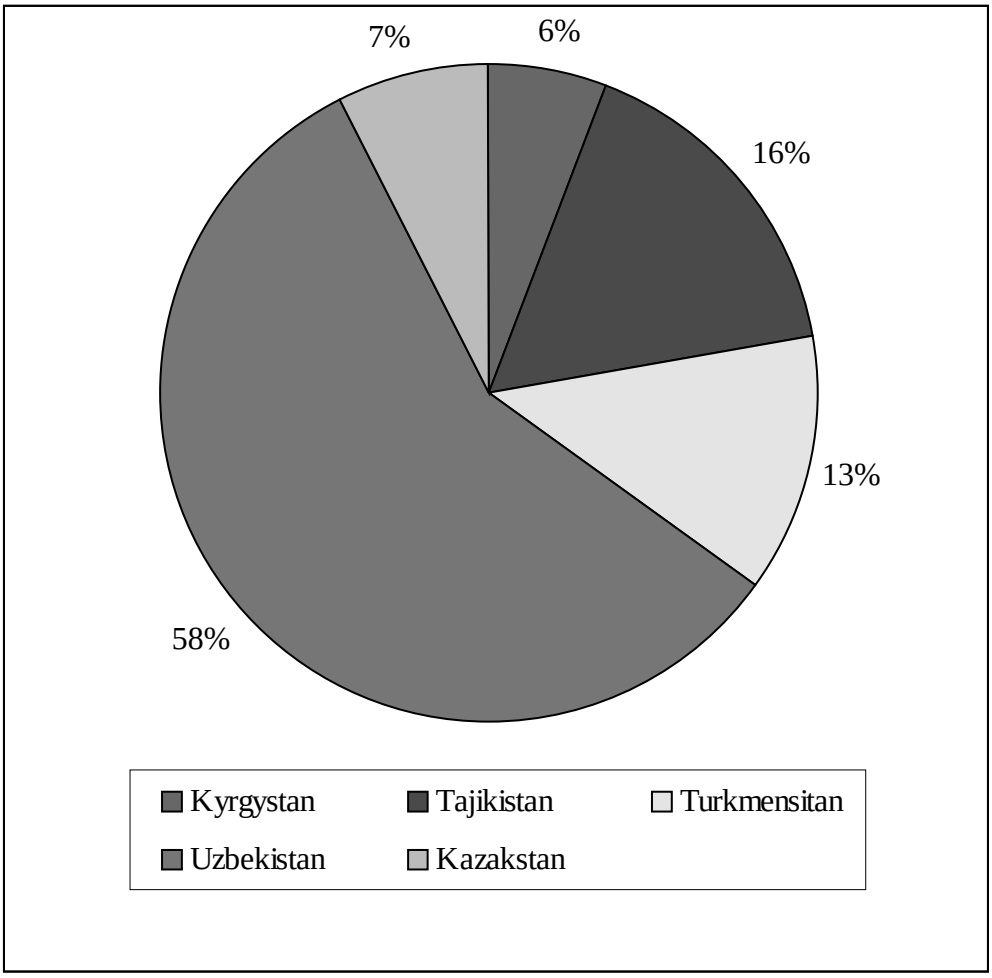

Figure 4.2: Present share of agricultural water in the Aral Sea basin.

Future uses of the water should also be considered. Each country has calculated the amount of land which can be irrigated after installing new irrigation methods by the year 2010. Table 4.5 shows that by the year 2010 only Kyrgyzstan and Turkmenistan plan to increase their water use.

Table 4.5: Documented irrigation (1994) and projected (2010) water use (World Bank, 1996).

	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan	Kazakstan
Irrigation Water Use (1994) km^3	4.9	10.3	23.3	53.4	9.7
Irrigation Water Use (2010) km^3	7.8	10.3	25.2	48.0	9.4

EXISTING TREATIES

The Interstate Commission for Water Coordination (ICWC) has worked on establishing an approach for limiting water consumption in the Amu Darya and Syr Darya, and on a common strategy for transboundary water resources management. The ICWC has also worked on establishing water allocations to each country so that the waters are used to their fullest capacity. Figure 4.3 shows the allocations the ICWC has given to each country. The water surplus, calculated according to the GIS model, is also shown in contrast to the water consumption in the Aral Sea basin. The ICWC allocates more water than is produced to Turkmenistan and Uzbekistan, who irrigate the largest amount of land, 1.7 million hectares and 4.2 million hectares, respectively.

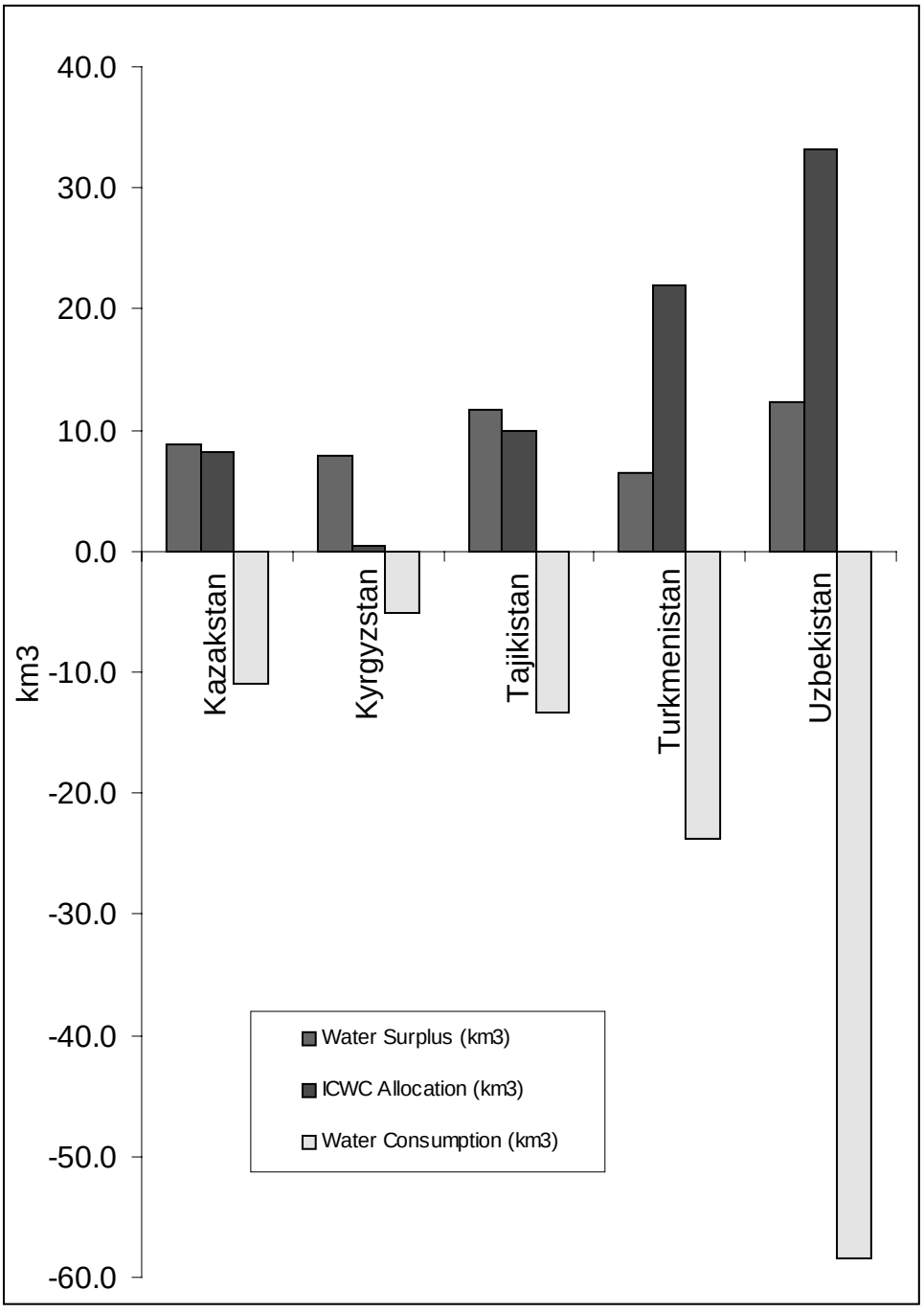

Figure 4.3: Water surplus, allocation, and consumption in the Aral Sea basin.

Syr Darya Basin

On September 12, 1997, the four countries of Kazakstan, Kyrgyzstan, Tajikistan and Uzbekistan signed an agreement on the use of the Syr Darya waters. This agreement occurred recognizing these countries had lived together for many generations. They therefore have common interests in developing efficient and coordinated water regime in the Syr Darya Basin taking into account the many environmental problems of the Aral Sea. The agreement is based on the proposed management and maintenance of the five reservoirs, Toktogul, Kairakum, Charvak, Chardarya, and Andizhan, found in the Syr Darya basins.

Article IV of this agreement declares that there will be compensation for energy loss as a result of their reduction of releases during the non-vegetative period (winter months). Compensation will be made using energy resources such as coal, gas, and electricity or their monetary equivalents. A tariff will be included in these exchanges based on costs of operation, maintenance and reconstruction of hydrotechnical facilities.

The treaty also declares that the four nations will seek agreement on the construction of new hydropower facilities, and promote the use of monetary exchange as a replacement for current energy exchanges. They also agree to reduce the amount of pollutions released to the river, and to develop water saving technologies.

The agreement is as follows: Kyrgyzstan receives 1.1 billion kWh of power in electricity or coal, valued at $22 million, and 400 million kWh of power plus 500 million cubic meters of gas, valued at $48.5 million, from Kazakstan and

Uzbekistan, respectively. In return Kyrgyzstan delivers 3.25 cubic kilometers of water from the Toktogul Reservoir in monthly flows and 1.1 billion kWh of summer hydroelectric power to both Kazakstan and Uzbekistan (Keith & McKinney, 1997).

Because Kazakstan and Uzbekistan benefit from timely water releases from Kyrgyz dams, it is fair that they pay for part of the maintenance and operation of the dams. The economies of these three countries are closely interrelated, and it is therefore important that they share natural resources. However, the fact that Uzbekistan pays more than Kazakstan for the same amount water and power could be disputed. Furthermore, is it fair that Uzbekistan and Kazakstan pay for the maintenance and operation of the dam plus pay for the water releases?

Amu Darya Basin

The biggest canal in Central Asia, the Karakum Canal, diverts 500 cubic meters per second from the middle of the Amu Darya to Turkmenistan. About 33 percent of the water used for irrigation in Turkmenistan percolates through the sandy soils of the canal. Furthermore, seepage losses are so enormous that they have created a 800 square kilometer lake alongside the Karakum canal.

Tajikistan exports 3.4 billion kWh ($170 million) of hydroelectric power to Uzbekistan from the Amu Darya dams. Tajikistan in exchange imports 3 billion kWh ($130 million) of electricity per year from Uzbekistan in the form of natural gas (BISNIS, 1997).

Figure 4.4 shows the water allocations of each country and the trade of resources between the countries. Tajikistan and Kyrgyzstan produce hydroelectric power which they trade along with water for coal and natural gas. The Amu Darya does not flow within the borders of Kyrgyzstan, however, the ICWC allocates 0.15 km^3 per year of Amu Darya water to Kyrgyzstan. By allocating Amu Darya water to Kyrgyzstan, the ICWC is able to alleviate some of the demand on the Syr Darya.

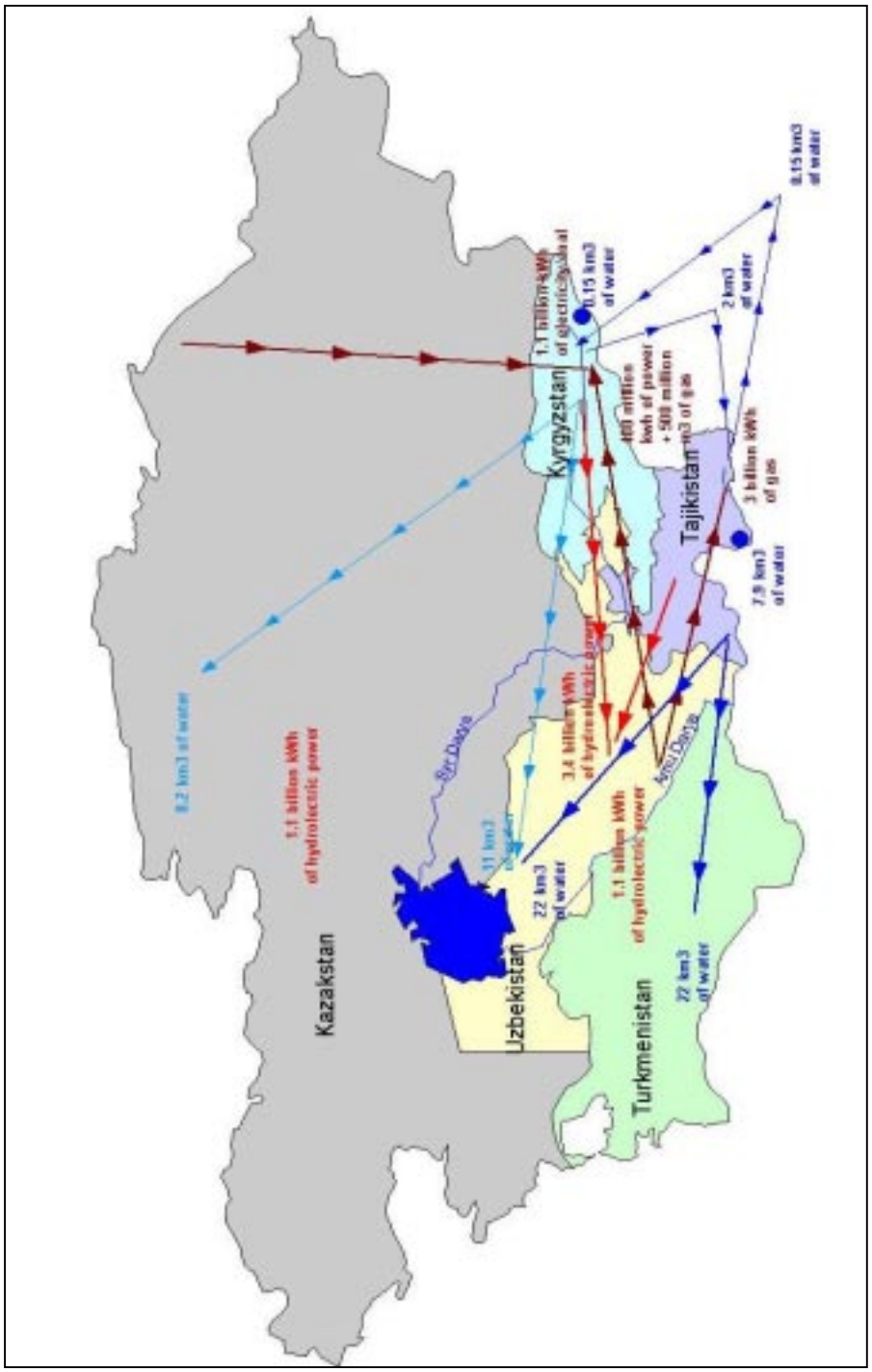

Figure 4.4: Exchange of resources in the Aral Sea basin.

ANALYSIS OF THE HELSINKI RULES

The Helsinki Rules have 11 main factors in determining water rights, of which seven have been analyzed throughout the preceding chapters; The extent of the drainage area in the territory of each basin State, the contribution of water by each basin State, the past utilization of the waters of the basin, the economic and social needs of each basin State, the population dependent on the waters of the basin in each basin State, and the availability of other resources. Table 4.6 classifies each country on a scale of 1 to 5, 1 being the strongest or best and 5 being the weakest or worst, when applied to the Helsinki Rules factors. It should be noted that classifying or ranking is a difficult task and many rankings could be argued as ties. The results show that the least dependent country on the Aral Sea basin is Turkmenistan, and the most dependent is Uzbekistan.

Table 4.6: Helsinki Rules ranking of each country (1= best, 5= worst).

	Kazakstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Watershed extent	3	5	4	2	1
Water Surplus Contribution	3	2	1	5	4
Social/Population independence	3	1	2	4	5
Economic independence	2	4	5	1	3
Optimization of water	4	1	2	3	5
Availability of other resources	2	4	5	1	3
Total score	17	17	19	16	21

4

The watershed extent and water surplus contribution are based on the GIS analysis in Figure 2.8 and Figure 2.18, respectively. The results for the watershed extent show how hard it is to classify: Uzbekistan has 1% more of the watershed

than Turkmenistan, while Turkmenistan has 5% more of the watershed, yet the rankings differ only by one point.

The social and population independence of each country from the Aral Sea basin are based on the amount of irrigated land; the larger the area, the larger amount of population is affected. Uzbekistan irrigates over 4.2 million hectares of land, thereby affecting a greatest amount of people. Furthermore, the population in Uzbekistan' region of Karakalpakstan is the most affected by the pollution and drying of the Aral Sea basin: The degradation of health near the Aral Sea is the most poignant dependence on the Aral Sea waters. Kyrgyzstan and Tajikistan are rated as the most socially independent countries due to their small amount of irrigated. It could easily argued, however, that the Kyrgyz and Tajiks are the most dependent on the Aral Sea basin due to their dependence on hydroelectric power as a form of electricity during the harsh winter months.

Economic independence is based on each country's GDP and the GDP's dependence on water resources. Turkmenistan is ranked the most independent because although it irrigates a large amount of land, agriculture only makes up 11% of the GDP, while industries make up 81%. Tajikistan ranked the lowest for economic independence; Although the amount of its GDP based on agriculture is low, it depends on the hydroelectric power as its most lucrative industry, and on the trading of water as an exchange for other natural resources. The same is true for Kyrgyzstan.

The optimization of water is dependent on how the country's use and optimization of available water. The downstream countries scored the lowest for

water optimizing because of their outdated irrigation techniques. These techniques, dating back to Soviet times, have some of the largest evaporation and infiltration rates in Central Asia. Many canals, like in Turkmenistan, have been made improperly causing water leaks and small lakes. Uzbekistan ranked the lowest due to its government agency, the MFER, subsidizing farmer's crops, no matter the price of the input nor the output, and therefore indirectly discouraging farmers from lowering water consumption.

Finally, Turkmenistan ranked the highest on the availability of other resources due to its oil and natural reserves. Tajikistan and Kyrgyzstan scored the lowest due to their extreme dependence on hydroelectric power as their only real power producing resource.

The true result of Table 4.6 is that the Helsinki Rules are hard to apply to real circumstances. The Helsinki Convention state that all factors are to be weighed equally, but ranking or classifying countries according to these factors is not discussed. Classifying a country as more or less needy, dependent, independent, poor or rich is not an easy task, and therefore shows the impracticality of the Helsinki Rules.

Chapter 5: Conclusions

GEOGRAPHIC INFORMATION SYSTEMS

Accomplishments

The GIS analysis of the spatial hydrology of the Aral Sea was conclusive and dependable. The amount of time necessary to do a spatial hydrologic study of a region without actually going "on the field" is one of GIS's best characteristics. The work accomplished through GIS for this thesis includes the following:

- Watershed and water stream delineation,
- Calculation of evaporation,
- Calculation of water surplus,
- Addition of snowmelt into the water surplus calculation,
- Percent of watershed,
- Percent of water surplus.

An advantage of using GIS is its reliability. Table 2.1 illustrates that documented values were only 0.2 to 6.2 percent greater than the calculated values of watershed extent. The documented values were gathered in 1989 at which time the water extent might have been greater than today, thereby justifying the smaller GIS values. The simple snowmelt program to calculate water surplus was beneficial. Table 2.2 shows the difference in using snowmelt for water surplus calculations. These values correlated well with documented values from the UNESCO.

Further Work

Further work could be done in the GIS study of the Aral Sea basin to increase the dependability of the water surplus values.

This work should include the following:

- Evaporation calculations should include a better understanding of how infiltration and evaporation occur on rock and glaciers.
- Runoff coefficients should be added for a better estimate of the water surplus.
- Snowpack values and the cycle of glacier melt should be included for a better estimate of snowmelt.
- Radiation should also be included for its effect on snowmelt.
- Water discharge used for irrigation should be used to calculate a complete water balance.

HELSINKI RULES

The Helsinki Rules were drafted by the United Nations without much consideration on how to apply the Convention to real situations. Although the Helsinki Rules have been quoted and cited by many nations in water disputes, its analysis in a particular circumstance had never been attempted before.

Analysis of the Helsinki Rules

The Helsinki Rules proved to be vague in determining water rights. Although the 12 points cited as factors in determining water rights are applicable to any situation, it is difficult to determine and to scale different degrees and ranges of economic, social, and population dependence on the Aral Sea waters.

Furthermore, the practicability of compensation to one or more of the co-basin States, the degree to which the needs of a basin State may be satisfied without causing substantial injury to a co-basin, and the comparative costs of alternative means of satisfying the economic and social needs of each basin state are extremely hard to study and answer.

The economic, social, environmental, and hydrological status of each Aral Sea basin country was analyzed and classified in Table 4.6. Table 4.6 clearly shows the difficulty of applying the Helsinki Rules to a case study. Ranking or classifying one country as more or less economically dependent relies on more than just GDP or employment numbers. Is water irrigation as a means of employment more "important" than water as a mean of producing electricity for cold winter months? It can be argued that without electricity, the population may literally freeze to death, as it can be argued that without work the population may have no money to pay for shelter or for food thereby literally dying of starvation. The importance of one industry over another is as subjective as the dependence of one country's economy on the Aral Sea basin over another, making the Helsinki Rules extremely hard to enforce.

The only nonsubjective factor in the Helsinki Rules is the hydrological analysis, and can therefore be applied to determine water rights. Furthermore, a broad analysis of each country's economic and social status can be applied without "ranking" or penalizing other countries.

Applying the Helsinki Rules

The upstream countries of Kyrgyzstan and Tajikistan are extremely dependent on the Amu Darya and Syr Darya. Without these waters, the upstream countries could not create the hydroelectric power which is essential due to their lack of other energy producing resources such as oil and natural gas. The downstream countries of the Kazakstan, Turkmenistan, and Uzbekistan also need the Syr Darya and Amu Darya; not for energy but for agriculture. Considering that the hydrology of the Aral Sea basin is "equal", i.e. the greatest extent of the watersheds is in the downstream countries, while the upstream countries produce the greatest amount of water runoff, the five Aral Sea countries should share the water.

The water should be shared so that the upstream countries can create hydropower during the winter months, and be compensated for water releases for downstream countries through the exchange of hard currency of fuel (natural gas or oil). Since the five countries are to share the waters, the operation and maintenance of hydrotechnical facilities should also be shared, with the greater contribution from the upstream countries. Because the downstream countries of Uzbekistan, Kazakstan, and Turkmenistan are the largest consumers of water and consume much more than their “share”, the upstream countries should be compensated for releasing more water. Therefore, the concept of the upstream countries of Tajikistan and Kyrgyzstan releasing water in exchange for natural gas and oil can be considered as fair.

It can be concluded that there should be equal sharing of the Aral Sea waters. In the event, that a country needs more than its share of water, the other countries should be compensated with other natural resources. However, this equal sharing or compensation should not precede the proper treatment of the Aral Sea basin. As water inflow to the Aral Sea continues to drop, it is of utmost importance that each of the Central Asian countries does its best to minimize and optimize its use of the Aral Sea waters.

Appendices

APPENDIX A:THE HELSINKI RULES ON THE USES OF THE WATERS OF INTERNATIONAL RIVERS (SOURCE: MFA)

CHAPTER 1. GENERAL

Article I

The general rules of international law as set forth in these chapters are applicable to the use of the waters of an international drainage basin except as may be provided otherwise by convention, agreement or binding custom among the basin States.

Article II

An international drainage basin is a geographical area extending over two or more States determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus.

Article III

A "basin State" is a State the territory of which includes a portion of an international drainage basin.

CHAPTER 2. EQUITABLE UTILIZATION OF THE WATERS OF AN INTERNATIONAL DRAINAGE BASIN

Article IV

Each basin State is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an international drainage basin.

Article V

I. What is a reasonable and equitable share within the meaning of article IV to be determined in the light of all the relevant factors in each particular case.
II. Relevant factors which are to be considered include, but are not limited to: The geography of the basin, including in particular the extent of the drainage area in the territory of each basin State;

The hydrology of the basin, including in particular the contribution of water by each basin State;
The climate affecting the basin;
The past utilization of the waters of the basin, including in particular existing utilization;
The economic and social needs of each basin State;
The population dependent on the waters of the basin in each basin State;
The comparative costs of alternative means of satisfying the economic and social needs of each basin State;
The availability of other resources;
The avoidance of unnecessary waste in the utilization of waters of the basin;
The practicability of compensation to one or more of the co-basin States as a means of adjusting conflicts among uses; and
The degree to which the needs of a basin State may be satisfied, without causing substantial injury to a co-basin State.
III. The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is reasonable and equitable share, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

Article VI

A use or category of uses is not entitled to any inherent preference over any other use or category of uses.

Article VII

A basin State may not be denied the present reasonable use of the waters of an international drainage basin to reserve for a co-basin State a future use of such waters.

Article VIII

An existing reasonable use may continue in operation unless the factors justifying its continuance are outweighed by other factors leading to the conclusion that it be modified or terminated so as to accommodate a competing incompatible use.
(a) A use that is in fact operational is deemed to have been an existing use from the time of the initiation of construction directly related to the use or, where such construction is not required, the undertaking of comparable acts of actual implementation.
(b) Such a use continues to be an existing use until such time as it is discontinued with the intention that it be abandoned.
A use will not be deemed an existing use if at the time of becoming operational it is incompatible with an already existing reasonable use.

CHAPTER 3. POLLUTION

Article IX

As used in this chapter, the term "water pollution" refers to any detrimental change resulting from human conduct in the natural composition, content, or quality of the waters of an international drainage basin.

Article X

1. Consistent with the principle of equitable utilization of the waters of an international drainage basin, a State:
(a) Must prevent any new form of water pollution or any increase in the degree of existing water pollution in an international drainage basin which would cause substantial injury in the territory of a co-basin State;
(b) Should take all reasonable measures to abate existing water pollution in an international drainage basin to such an extent that no substantial damage is caused in the territory of a co-basin State.
2. The rule stated in paragraph 1 of this article applies to water pollution originating:
(a) Within a territory of the State, or
(b) Outside the territory of the State, if it is caused by the State's conduct.
Article XI
In the case of a violation of the rule stated in paragraph 1 (a) of article X of this chapter, the State responsible shall be required to cease the wrongful conduct and compensate the injured co-basin State for the injury that has been caused to it.
In a case falling under the rule stated in paragraph 1 (b) of article X, if a State fails to take reasonable measures, it shall be required promptly to enter into negotiations with the injured State with a view towards reaching a settlement equitable under the circumstances.

CHAPTER 4 . NAVIGATION (Articles XII-XX)

CHAPTER 5. TIMBER FLOATING (ArticlesXXI-XXV)

CHAPTER 6. PROCEDURES FOR THE PREVENTION AND SETTLEMENT OF DISPUTES

Article XXVI

This chapter relates to procedures for the prevention and settlement of international disputes as to the legal rights or other interests of basin States and of other States in the waters of an international drainage basin.

Article XXVII

Consistently with the Charter of the United Nations, States are under an obligation to settle international disputes as to their legal rights or other interests by peaceful means in such a manner that international peace and security and justice are not endangered.

It is recommended that States resort progressively to the means of prevention and settlement of disputes stipulated in articles XXIX to XXXIV of this chapter.

Article XXVIII

1. States are under a primary obligation to resort to means of prevention and settlement of disputes stipulated in the applicable treaties binding upon them.
2. States are limited to the means of prevention and settlement of disputes stipulated in treaties binding upon them only to the extent provided by the applicable treaties.

Article XXIX

With a view to preventing disputes from arising between basin States as to their legal rights or other interest, it is recommended that each basin State furnish relevant and reasonably available information to the other basin States concerning the waters of a drainage basin within its territory and its use of, and activities with respect to, such waters.

A State, regardless of its location in a drainage basin, should in particular furnish to any other basin State, the interests of which may be substantially affected, notice of any proposed construction or installation which would alter the regime of the basin in a way which might give rise to a dispute as defined in article XXVI. The notice should include such essential facts as will permit the recipient to make an assessment of the probable effect of the proposed alteration.

A State providing the notice referred to in paragraph 2 of this article should afford the recipient a reasonable period of time to make an assessment of the probable effect of the proposed construction or installation and to submit its views thereon to the State furnishing the notice.

If a State has failed to give the notice referred to in paragraph 2 of this article, the alteration by the State in the regime of the drainage basin shall not be given the weight normally accorded to temporal priority in use in the event of a determination of what is a reasonable and equitable share of the waters of the basin.

Article XXX

In case of a dispute between States as to their legal rights or other interests, as defined in article XXVI, they should seek a solution by negotiation..

Article XXXI

If a question or dispute arises which relates to the present or future utilization of the waters of an international drainage basin, it is recommended that the basin States refer the question or dispute to a joint agency and that they request the agency to survey the international drainage basin and to formulate plans or recommendations for the fullest and most efficient use thereof in the interests of all such States.

It is recommended that the joint agency be instructed to submit reports on all matters within its competence to the appropriate authorities of the member States concerned.

It is recommended that the member States of the joint agency in appropriate cases invite non-basin States which by treaty enjoy a right in the use of the waters of an international drainage basin to associate themselves with the work of the joint agency or that they be permitted to appear before the agency.

Article XXXII

If a question or a dispute is one which is considered by the States concerned to be incapable of resolution in the manner set forth in article XXXI, it is recommended that they seek the good offices, or jointly request the mediation of a third State, of a qualified international organization or of a qualified person.

Article XXXIII

1. If the States concerned have not been able to resolve their dispute through negotiation or have been unable to agree on the measures described in articles XXXI and XXXII, it is recommended that they form a commission of inquiry or an ad hoc conciliation commission, which shall endeavor to find a solution, likely to be accepted by the States concerned, of any dispute as to their legal rights.

2. It is recommended that the conciliation commission be constituted in the manner set forth in the annex.

Article XXXIV

It is recommended that the States concerned agree to submit their legal disputes to an ad hoc arbitral tribunal, to a permanent arbitral tribunal or to the International Court of Justice if:

(a) A commission has not been formed as provided in article XXXIII, or

(b) The commission has not been able to find a solution to be recommended, or

(c) A solution recommendedhas not been accepted by the States concerned, and

(d) An agreement has not been otherwise arrived at.

Article XXXV

It is recommended that in the event of arbitration the States concerned have recourse to the Model Rules on Arbitral Procedure prepared by the International Law Commission of the United Nations at its tenth session b/in 1958.

Article XXXVI

Recourse to arbitration implies the undertaking by the States concerned to consider the award to be given as final and to submit in good faith to its execution.

Article XXXVII

The means of settlement referred to in the preceding articles of this chapter are without prejudice to the utilization of means of settlement recommended to, or required of, members of regional arrangements or agencies and of other international organizations.

a/ Adopted by the International Law Association at the fifty-second conference, held at Helsinki in August 1966. Report of the Committee on the Uses of the Waters of International Rivers (London, International Law Association, 1967).

APPENDIX B: CONVENTION ON THE LAW OF THE NON-NAVIGATIONAL USES OF INTERNATIONAL WATERCOURSES ADOPTED BY THE UN GENERAL ASSEMBLY MAY 1997

The Parties to the present Convention, Conscious of the importance of international watercourses and the non-navigational uses thereof in many regions of the world, Having in mind Article 13, paragraph 1 (a), of the Charter of the United Nations, which provides that the General Assembly shall initiate studies and make recommendations for the purpose of encouraging the progressive development of international law and its codification, Considering that successful codification and progressive development of rules of international law regarding non-navigational uses of international watercourses would assist in promoting and implementing the purposes and principles set forth in Articles 1 and 2 of the Charter of the United Nations, Taking into account the problems affecting many international watercourses resulting from, among other things, increasing demands and pollution, Expressing the conviction that a framework convention will ensure the utilization, development, conservation, management and protection of international watercourses and the promotion of the optimal and sustainable utilization thereof for present and future generations Affirming the importance of international cooperation and good neighbourliness in this field, Aware of the special situation and needs of developing countries, Recalling the principles and recommendations adopted by the United Nations Conference on Environment and Development of 1992 in the Rio Declaration and Agenda 21, Recalling also the existing bilateral and multilateral agreements regarding the non-navigational uses of international watercourses, Mindful of the valuable contribution of international organizations, both governmental and non-governmental, to the codification and progressive development of international law in this field, Appreciative of the work carried out by the International Law Commission on the law of the non-navigational uses of international watercourses, Bearing in mind United Nations General Assembly resolution 49/52 of 9 December 1994, Have agreed as follows:

Part I. Introduction

Article 1

Scope of the present Convention

1. The present Convention applies to uses of international watercourses and of their waters for purposes other than navigation and to measures of protection, preservation and management related to the uses of those watercourses and their waters.

The uses of international watercourses for navigation is not within the scope of the present Convention except insofar as other uses affect navigation or are affected by navigation.

Article 2

Use of terms

For the purposes of the present Convention:

"Watercourse" means a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus;

"International watercourse" means a watercourse, parts of which are situated in different States;

"Watercourse State" means a State Party to the present Convention in whose territory part of an international watercourse is situated, or a Party that is a regional economic integration organization, in the territory of one or more of whose Member States part of an international watercourse is situated;

"Regional economic integration organization" means an organization constituted by sovereign States of a given region, to which its member States have transferred competence in respect of matters governed by this Convention and which has been duly authorized in accordance with its internal procedures, to sign, ratify, accept, approve or accede to it.

Article 3

Watercourse agreements

In the absence of an agreement to the contrary, nothing in the present Convention shall affect the rights or obligations of a watercourse State arising from agreements in force for it on the date on which it became a party to the present Convention.

Notwithstanding the provisions of paragraph 1, parties to agreements referred to in paragraph 1 may, where necessary, consider harmonizing such agreements with the basic principles of the present Convention.

Watercourse States may enter into one or more agreements, hereinafter referred to as "watercourse agreements", which apply and adjust the provisions of the present Convention to the characteristics and uses of a particular international watercourse or part thereof.

Where a watercourse agreement is concluded between two or more watercourse States, it shall define the waters to which it applies. Such an agreement may be entered into with respect to an entire international watercourse or any part thereof or a particular project programme or use except insofar as the

agreement adversely affects, to a significant extent, the use by one or more other watercourse States of the waters of the watercourse, without their express consent.

Where a watercourse State considers that adjustment and application of the provisions of the present Convention is required because of the characteristics and uses of a particular international watercourse, watercourse States shall consult with a view to negotiating in good faith for the purpose of concluding a watercourse agreement or agreements.

Where some but not all watercourse States to a particular international watercourse are parties to an agreement, nothing in such agreement shall affect the rights or obligations under the present Convention of watercourse States that are not parties to such an agreement.

Article 4

Parties to watercourse agreements

1. Every watercourse State is entitled to participate in the negotiation of and to become a party to any watercourse agreement that applies to the entire international watercourse, as well as to participate in any relevant consultations.

2. A watercourse State whose use of an international watercourse may be affected to a significant extent by the implementation of a proposed watercourse agreement that applies only to a part of the watercourse or to a particular project, programme or use is entitled to participate in consultations on such an agreement and, where appropriate, in the negotiation thereof in good faith with a view to becoming a party thereto, to the extent that its use is thereby affected.

PART II. GENERAL PRINCIPLES

Article 5

Equitable and reasonable utilization and participation

1. Watercourse States shall in their respective territories utilize an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be used and developed by watercourse States with a view to attaining optimal and sustainable utilization thereof and benefits therefrom, taking into account the interests of the watercourse States concerned, consistent with adequate protection of the watercourse.

2. Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection and development thereof, as provided in the present Convention.

Article 6

Factors relevant to equitable and reasonable utilization

1. Utilization of an international watercourse in an equitable and reasonable manner within the meaning of article 5 requires taking into account all relevant factors and circumstances, including:

Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character;

The social and economic needs of the watercourse States concerned;

The population dependent on the watercourse in each watercourse State;

The effects of the use or uses of the watercourses in one watercourse State on other watercourse States;

Existing and potential uses of the watercourse;

Conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect;

The availability of alternatives, of comparable value, to a particular planned or existing use.

2. In the application of article 5 or paragraph 1 of this article, watercourse States concerned shall, when the need arises, enter into consultations in a spirit of cooperation.

3. The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable use, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

Article 7

Obligation not to cause significant harm

1. Watercourse States shall, in utilizing an international watercourse in their territories, take all appropriate measures to prevent the causing of significant harm to other watercourse States.

2. Where significant harm nevertheless is caused to another watercourse State, the States whose use causes such harm shall, in the absence of agreement to such use, take all appropriate measures, having due regard for the provisions of articles 5 and 6, in consultation with the affected State, to eliminate or mitigate such harm and, where appropriate, to discuss the question of compensation.

Article 8

General obligation to cooperate

1. Watercourse States shall cooperate on the basis of sovereign equality, territorial integrity, mutual benefit and good faith in order to attain optimal utilization and adequate protection of an international watercourse.

In determining the manner of such cooperation, watercourse States may consider the establishment of joint mechanisms or commissions, as deemed necessary by them, to facilitate cooperation on relevant measures and procedures in the light of experience gained through cooperation in existing joint mechanisms and commissions in various regions.

Article 9

Regular exchange of data and information

1. Pursuant to article 8, watercourse States shall on a regular basis exchange readily available data and information on the condition of the watercourse, in particular that of a hydrological, meteorological, hydrogeological and ecological nature and related to the water quality as well as related forecasts.

2. If a watercourse State is requested by another watercourse State to provide data or information that is not readily available, it shall employ its best efforts to comply with the request but may condition its compliance upon payment by the requesting State of the reasonable costs of collecting and, where appropriate, processing such data or information.

3. Watercourse States shall employ their best efforts to collect and, where appropriate, to process data and information in a manner which facilitates its utilization by the other watercourse States to which it is communicated.

Article 10

Relationship between different kinds of uses

1. In the absence of agreement or custom to the contrary, no use of an international watercourse enjoys inherent priority over other uses.

2. In the event of a conflict between uses of an international watercourse, it shall be resolved with reference to articles 5 to 7, with special regard being given to the requirements of vital human needs.

PART III. PLANNED MEASURES

Article 11

Information concerning planned measures

Watercourse States shall exchange information and consult each other and, if necessary, negotiate on the possible effects of planned measures on the condition of an international watercourse.

Article 12

Notification concerning planned measures with possible adverse effects

Before a watercourse State implements or permits the implementation of planned measures which may have a significant adverse effect upon other watercourse States, it shall provide those States with timely notification thereof. Such notification shall be accompanied by available technical data and information, including the results of any environmental impact assessment, in order to enable the notified States to evaluate the possible effects of the planned measures.

Article 13

Period for reply to notification

Unless otherwise agreed:

(a) A watercourse State providing a notification under article 12 shall allow the notified States a period of six months within which to study and evaluate the possible effects of the planned measures and to communicate the findings to it;

(b) This period shall, at the request of a notified State for which the evaluation of the planned measures poses special difficulty, be extended for a period of six months.

Article 14

Obligations of the notifying State during the period for reply

During the period referred to in article 13, the notifying State:

(a) Shall cooperate with the notified States by providing them, on request, with any additional data and information that is available and necessary for an accurate evaluation; and

(b) Shall not implement or permit the implementation of the planned measures without the consent of the notified States.

Article 15

Reply to notification

The notified States shall communicate their findings to the notifying State as early as possible within the period applicable pursuant to article 13. If a notified State finds that implementation of the planned measures would be inconsistent with the provisions of articles 5 or 7, it shall attach to its finding a documented explanation setting forth the reasons for the finding.

Article 16

Absence of reply to notification

1. If, within the period applicable pursuant to article 13, the notifying State receives no communication under article 15, it may, subject to its obligations under articles 5 and 7, proceed with the implementation of the planned measures, in accordance with the notification and any other data and information provided to the notified States.

2. Any claim to compensation by a notified State which has failed to reply within the period applicable pursuant to article 13 may be offset by the costs incurred by the notifying State for action undertaken after the expiration of the time for a reply which would not have been undertaken if the notified State had objected within that period.

Article 17

Consultations and negotiations concerning planned measures

1. If a communication is made under article 15 that implementation of the planned measures would be inconsistent with the provisions of articles 5 or 7, the notifying State and the State making the communication shall enter into consultations and, if necessary, negotiations with a view to arriving at an equitable resolution of the situation.

2. The consultations and negotiations shall be conducted on the basis that each State must in good faith pay reasonable regard to the rights and legitimate interests of the other State.

3. During the course of the consultations and negotiations, the notifying State shall, if so requested by the notified State at the time it makes the communication, refrain from implementing or permitting the implementation of the planned measures for a period of six months unless otherwise agreed.

Article 18

Procedures in the absence of notification

1. If a watercourse State has reasonable grounds to believe that another watercourse State is planning measures that may have a significant adverse effect upon it, the former State may request the latter to apply the provisions of article 12. The request shall be accompanied by a documented explanation setting forth its grounds.

2. In the event that the State planning the measures nevertheless finds that it is not under an obligation to provide a notification under article 12, it shall so inform the other State, providing a documented explanation setting forth the reasons for such finding. If this finding does not satisfy the other State, the two States shall, at the request of that other State, promptly enter into consultations and negotiations in the manner indicated in paragraphs 1 and 2 of article 17.

3. During the course of the consultations and negotiations, the State planning the measures shall, if so requested by the other State at the time it requests the initiation of consultations and negotiations, refrain from implementing or permitting the implementation of those measures for a period of six months unless otherwise agreed.

Article 19

Urgent implementation of planned measures

1. In the event that the implementation of planned measures is of the utmost urgency in order to protect public health, public safety or other equally important interests, the State planning the measures may, subject to articles 5 and 7, immediately proceed to implementation, notwithstanding the provisions of article 14 and paragraph 3 of article 17.

2. In such case, a formal declaration of the urgency of the measures shall be communicated without delay to the other watercourse States referred to in article 12 together with the relevant data and information.

3. The State planning the measures shall, at the request of any of the States referred to in paragraph 2, promptly enter into consultations and negotiations with it in the manner indicated in paragraphs 1 and 2 of article 17.

PART IV. PROTECTION, PRESERVATION AND MANAGEMENT

Article 20

Protection and preservation of ecosystems

Watercourse States shall, individually and, where appropriate, jointly, protect and preserve the ecosystems of international watercourses.

Article 21

Prevention, reduction and control of pollution

1. For the purpose of this article, "pollution of an international watercourse" means any detrimental alteration in the composition or quality of the waters of an international watercourse which results directly or indirectly from human conduct.

2. Watercourse States shall, individually and, where appropriate, jointly, prevent, reduce and control the pollution of an international watercourse that may cause significant harm to other watercourse States or to their environment, including harm to human health or safety, to the use of the waters for any beneficial purpose or to the living resources of the watercourse. Watercourse States shall take steps to harmonize their policies in this connection.

Watercourse States shall, at the request of any of them, consult with a view to arriving at mutually agreeable measures and methods to prevent, reduce and control pollution of an international watercourse, such as:

(a) Setting joint water quality objectives and criteria;

(b) Establishing techniques and practices to address pollution from point and non-point sources;

(c) Establishing lists of substances the introduction of which into the waters of an international watercourse is to be prohibited, limited, investigated or monitored.

Article 22

Introduction of alien or new species

Watercourse States shall take all measures necessary to prevent the introduction of species, alien or new, into an international watercourse which may have effects detrimental to the ecosystem of the watercourse resulting in significant harm to other watercourse States.

Article 23

Protection and preservation of the marine environment

Watercourse States shall, individually and, where appropriate, in cooperation with other States, take all measures with respect to an international watercourse that are necessary to protect and preserve the marine environment, including estuaries, taking into account generally accepted international rules and standards.

Article 24

Management

1. Watercourse States shall, at the request of any of them, enter into consultations concerning the management of an international watercourse, which may include the establishment of a joint management mechanism.

2. For the purposes of this article, "management" refers, in particular, to:

(a) Planning the sustainable development of an international watercourse and providing for the implementation of any plans adopted; and

(b) Otherwise promoting the rational and optimal utilization, protection and control of the watercourse.

Article 25

Regulation

1. Watercourse States shall cooperate, where appropriate, to respond to needs or opportunities for regulation of the flow of the waters of an international watercourse.

2. Unless otherwise agreed, watercourse States shall participate on an equitable basis in the construction and maintenance or defrayal of the costs of such regulation works as they may have agreed to undertake.

3. For the purposes of this article, "regulation" means the use of hydraulic works or any other continuing measure to alter, vary or otherwise control the flow of the waters of an international watercourse.

Article 26

Installations

1. Watercourse States shall, within their respective territories, employ their best efforts to maintain and protect installations, facilities and other works related to an international watercourse.

2. Watercourse States shall, at the request of any of them which has reasonable grounds to believe that it may suffer significant adverse effects, enter into consultations with regard to:

(a) The safe operation and maintenance of installations, facilities or other works related to an international watercourse; and

(b) The protection of installations, facilities or other works from wilful or negligent acts or the forces of nature.

PART V. HARMFUL CONDITIONS AND EMERGENCY SITUATIONS

Article 27

Prevention and mitigation of harmful conditions

Watercourse States shall, individually and, where appropriate, jointly, take all appropriate measures to prevent or mitigate conditions related to an international watercourse that may be harmful to other watercourse States,

whether resulting from natural causes or human conduct, such as flood or ice conditions, water-borne diseases, siltation, erosion, salt-water intrusion, drought or desertification.

Article 28

Emergency situations

1. For the purposes of this article, "emergency" means a situation that causes, or poses an imminent threat of causing, serious harm to watercourse States or other States and that results suddenly from natural causes, such as floods, the breaking up of ice, landslides or earthquakes, or from human conduct, such as industrial accidents.

2. A watercourse State shall, without delay and by the most expeditious means available, notify other potentially affected States and competent international organizations of any emergency originating within its territory.

3. A watercourse State within whose territory an emergency originates shall, in cooperation with potentially affected States and, where appropriate, competent international organizations, immediately take all practicable measures necessitated by the circumstances to prevent, mitigate and eliminate harmful effects of the emergency.

4. When necessary, watercourse States shall jointly develop contingency plans for responding to emergencies, in cooperation, where appropriate, with other potentially affected States and competent international organizations.

PART VI. MISCELLANEOUS PROVISIONS

Article 29

International watercourses and installations in time of armed conflict

International watercourses and related installations, facilities and other works shall enjoy the protection accorded by the principles and rules of international law applicable in international and non-international armed conflict and shall not be used in violation of those principles and rules.

Article 30

Indirect procedures

In cases where there are serious obstacles to direct contacts between watercourse States, the States concerned shall fulfil their obligations of cooperation provided for in the present Convention, including exchange of data and information, notification, communication, consultations and negotiations, through any indirect procedure accepted by them.

Article 31

Data and information vital to national defence or security

Nothing in the present Convention obliges a watercourse State to provide data or information vital to its national defence or security. Nevertheless, that State shall cooperate in good faith with the other watercourse States with a view to providing as much information as possible under the circumstances.

Article 32

Non-discrimination

Unless the watercourse States concerned have agreed otherwise for the protection of the interests of persons, natural or juridical, who have suffered or are under a serious threat of suffering significant transboundary harm as a result of activities related to an international watercourse, a watercourse State shall not discriminate on the basis of nationality or residence or place where the injury occurred, in granting to such persons, in accordance with its legal system, access to judicial or other procedures, or a right to claim compensation or other relief in respect of significant harm caused by such activities carried on in its territory.

Article 33

Settlement of disputes

1. In the event of a dispute between two or more Parties concerning the interpretation or application of the present Convention, the Parties concerned shall, in the absence of an applicable agreement between them, seek a settlement of the dispute by peaceful means in accordance with the following provisions.

2. If the Parties concerned cannot reach agreement by negotiation requested by one of them, they may jointly seek the good offices of, or request mediation or conciliation by, a third party, or make use, as appropriate, of any joint watercourse institutions that may have been established by them or agree to submit the dispute to arbitration or to the International Court of Justice.

3. Subject to the operation of paragraph 10, if after six months from the time of the request for negotiations referred to in paragraph 2, the Parties concerned have not been able to settle their dispute through negotiation or any other means referred to in paragraph 2, the dispute shall be submitted, at the request of any of the parties to the dispute, to impartial fact-finding in accordance with paragraphs 4 to 9, unless the Parties otherwise agree.

A Fact-finding Commission shall be established, composed of one member nominated by each Party concerned and in addition a member not having the nationality of any of the Parties concerned chosen by the nominated members who shall serve as Chairman.

5. If the members nominated by the Parties are unable to agree on a Chairman within three months of the request for the establishment of the Commission, any Party concerned may request the Secretary-General of the United Nations to appoint the Chairman who shall not have the nationality of any of the parties to the dispute or of any riparian State of the watercourse concerned. If one of the Parties fails to nominate a member within three months of the initial request pursuant to paragraph 3, any other Party concerned may request the

Secretary-General of the United Nations to appoint a person who shall not have the nationality of any of the parties to the dispute or of any riparian State of the watercourse concerned. The person so appointed shall constitute a single-member Commission.

6. The Commission shall determine its own procedure.

7. The Parties concerned have the obligation to provide the Commission with such information as it may require and, on request, to permit the Commission to have access to their respective territory and to inspect any facilities, plant, equipment, construction or natural feature relevant for the purpose of its inquiry.

8. The Commission shall adopt its report by a majority vote, unless it is a single-member Commission, and shall submit that report to the Parties concerned setting forth its findings and the reasons therefor and such recommendations as it deems appropriate for an equitable solution of the dispute, which the Parties concerned shall consider in good faith.

9. The expenses of the Commission shall be borne equally by the Parties concerned

10. When ratifying, accepting, approving or acceding to the present Convention, or at any time thereafter, a Party which is not a regional economic integration organization may declare in a written instrument submitted to the Depositary that, in respect of any dispute not resolved in accordance with paragraph 2, it recognizes as compulsory ipso facto and without special agreement in relation to any Party accepting the same obligation:

(a) Submission of the dispute to the International Court of Justice; and/or

(b) Arbitration by an arbitral tribunal established and operating, ’unless the parties to the dispute otherwise agreed, in accordance with the procedure laid down in the annex to the present Convention.

A Party which is a regional economic integration organization may make a declaration with like effect in relation to arbitration in accordance with subparagraph (b).

PART VII. FINAL CLAUSES

Article 34

Signature

The present Convention shall be open for signature by all States and by regional economic integration organizations from ... until ... at United Nations Headquarters in New York.

Article 35

Ratification, acceptance, approval or accession

1. The present Convention is subject to ratification, acceptance, approval or accession by States and by regional economic integration organizations. The instruments of ratification, acceptance, approval or accession shall be deposited with the Secretary-General of the United Nations.

2. Any regional economic integration organization which becomes a Party to this Convention without any of its member States being a Party shall be bound by all the obligations under the Convention. In the case of such organizations, one or more of whose member States is a Party to this Convention, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under the Convention. In such cases, the organization and the member States shall not be entitled to exercise rights under the Convention concurrently.

3. In their instruments of ratification, acceptance, approval or accession, the regional economic integration organizations shall declare the extent of their competence with respect to the matters governed by the Convention. These organizations shall also inform the Secretary-General of the United Nations of any substantial modification in the extent of their competence.

Article 36

Entry into force

1. The present Convention shall enter into force on the ninetieth day following the date of deposit of the thirty-fifth instrument of ratification, acceptance, approval or accession with the Secretary-General of the United Nations.

2. For each State or regional economic integration organization that ratifies, accepts or approves the Convention or accedes thereto after the deposit of the thirty-fifth instrument of ratification, acceptance, approval or accession, the Convention shall enter into force on the ninetieth day after the deposit by such State or regional economic integration organization of its instrument of ratification, acceptance, approval or accession.

3. For the purposes of paragraphs 1 and 2, any instrument deposited by a regional economic integration organization shall not be counted as additional those deposited by States.

Article 37

Authentic texts

The original of the present Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

IN WITNESS WHEREOF the undersigned plenipotentiaries, being duly authorized thereto, have signed this Convention.

DONE at New York, this _____ day of one thousand nine hundred and ninety-seven.

ANNEX

ARBITRATION

Article 1

Unless the parties to the dispute otherwise agree, the arbitration pursuant to article 33 of the Convention shall take place in accordance with articles 2 to 14 of the present annex.

Article 2

The claimant party shall notify the respondent party that it is referring a dispute to arbitration pursuant to article 33 of the Convention. The notification shall state the subject matter of arbitration and include, in particular, the articles of the Convention, the interpretation or application of which are at issue. If the parties do not agree on the subject matter of the dispute, the arbitral tribunal shall determine the subject matter.

Article 3

1. In disputes between two parties, the arbitral tribunal shall consist of three members. Each of the parties to the dispute shall appoint an arbitrator and the two arbitrators so appointed shall designate by common agreement the third arbitrator, who shall be the Chairman of the tribunal. The latter shall not' be a national of one of the parties to the dispute or of any riparian State of the watercourse concerned, nor have his or her usual place of residence in the territory of one of these parties or such riparian State, nor have dealt with the case in any other capacity.

2. In disputes between more than two parties, parties in the same interest shall appoint one arbitrator jointly by agreement.

3. Any vacancy shall be filled in the manner prescribed for the initial appointment.

Article 4

1. If the Chairman of the arbitral tribunal has not been designated within two months of the appointment of the second arbitrator, the President of the International Court of Justice shall, at the request of a party, designate the Chairman within a further two-month period.

2. If one of the parties to the dispute does not appoint an arbitrator within two months of receipt of the request, the other party may inform the President of the International Court of Justice, who shall make the designation within a further two-month period.

Article 5

The arbitral tribunal shall render its decisions in accordance with the provisions of this Convention and international law.

Article 6

Unless the parties to the dispute otherwise agree, the arbitral tribunal shall determine its own rules of procedure.

Article 7

The arbitral tribunal may, at the request of one of the Parties, recommend essential interim measures of protection.

Article 8

1. The parties to the dispute shall facilitate the work of the arbitral tribunal and, in particular, using all means at their disposal, shall:

(a) Provide it with all relevant documents, information and facilities; and

(b) Enable it', when necessary, to call witnesses or experts and receive their evidence.

2. The parties and the arbitrators are under an obligation to protect the confidentiality of any information they receive in confidence during the proceedings of the arbitral tribunal.

Article 9

Unless the arbitral tribunal determines otherwise because of the particular circumstances of the case, the costs of the tribunal shall be borne by the parties to the dispute in equal shares. The tribunal shall keep a record of all its costs, and shall furnish a final statement thereof to the parties.

Article 10

Any Party that has an interest of a legal nature in the subject matter of the dispute which may be affected by the decision in the case, may intervene in the proceedings with the consent of the tribunal.

Article 11

The tribunal may hear and determine counterclaims arising directly out of the subject matter of the dispute.

Article 12

Decisions both on procedure and substance of the arbitral tribunal shall be taken by a majority vote of its members.

Article 13

If one of the parties to the dispute does not appear before the arbitral tribunal or fails to defend its case, the other party may request the tribunal to continue the proceedings and to make its award. Absence of a party or a failure of a party to defend its case shall not constitute a bar to the proceedings. Before rendering its final decision, the arbitral tribunal must satisfy itself that the claim is well founded in fact and law.

Article 14

1. The tribunal shall render its final decision within five months of the date on which it is fully constituted unless it finds it necessary to extend the time limit for a period which should not exceed five more months.

2. The final decision of the arbitral tribunal shall be confined to the subject matter of the dispute and shall state the reasons on which it is based'. It shall contain the names of the members who have participated and the date of the final decision. Any member of the tribunal may attach a separate or dissenting opinion to the final decision.

3. The award shall be binding on the parties to the dispute. It shall be without appeal unless the parties to the dispute have agreed in advance to an appellate procedure.

4. Any controversy which may arise between the parties to the dispute as regards the interpretation or manner of implementation of the final decision may be submitted by either party for decision to the arbitral tribunal which rendered it.

Notes

1 For the report of the Sixth Committee on the work of the Working Group at its first session, held from 7 to 25 October 1996, see document A/51/624.

2 Official Records of the General Assembly, Forty-ninth Session, Supplement No. 10 (A/49/10), chap. III.D.

APPENDIX C: PROJECTION FILES

I. Albers Projection

```
input
projection albers
units meters
datum WGS84
parameters
26 32 0.000
44 36 0.000
43 42 0.000
42 0 0.000
0.00000
0.00000
output
projection geographic
units dd
datum wgs84
parameters
end
```

II. Transvers Projection

```
projection transverse
units meters
datum NONE
spheroid KRASOVSKY
parameters
1.00000
69 0 0.000
0 0 0.0000
12500000.000
0.00000
output
projection albers
units meters
datum WGS84
parameters
26 32 0.000
44 36 0.000
43 42 0.000
```

42 0 0.000
0.00000
0.00000
end

APPENDIX D: DELINEATION AML

```
/************************************************************
/* NAME: delin.aml
/* BY: Sean Reed
/* PURPOSE: Delineate drainage network and watersheds using a
/* digital elevation model.
/* INPUTS: delineation threshold and name of filled DEM
/* For information on how to obtain and fill a DEM see
/* http://www.ce.utexas.edu/prof/maidment/GISHydro/docs/amls/wtrshd.htm
/*  OUTPUTS: stream grid, stream coverage (covstr), and polygon coverage
/* (covwsh).
/*  COMMENTS:  This script should be executed from within Grid.
/************************************************************
project grid watergrid gridw_alb alb.prj
grid
&type [date -time]
fill gridw_alb map_fill
/* INITIALIZE NAMES OF INPUT GRIDS AND THRESHOLD VALUE
&sv fill = map_fill
&if [exists fdr -grid] &then
  kill fdr all
&if [exists fac -grid] &then
  kill fac all
&if [exists covstr -cover] &then
  kill covstr all
&if [exists covwsh -cover] &then
  kill covwsh all
fdr = flowdirection(%fill%)
fac = flowaccumulation(fdr)
/*&sv thrd = [response 'Enter a delineation threshold']
&sv thrd = 10000
&sv covname = covstr
&sv wshname = covwsh
/* ELIMINATE GRIDS FROM PREVIOUS RUNS
&if [exists str -grid] &then
  kill str all
&if [exists lnk -grid] &then
  kill lnk all
&if [exists znv -grid] &then
  kill znv all
```

```
&if [exists out -grid] &then
  kill out all
&if [exists wsh -grid] &then
  kill wsh all
/* BEGIN CALCULATIONS
/* Identify all cells with a flowaccumulation greater than the threshold value.
str = con ( fac gt %thrd%, 1 )
/* Assign a unique value to cells in separate stream reaches.
lnk = streamlink ( str, fdr )
/*&if [exists str -grid] &then
/*  kill str all
/* Convert a grid of links into a line coverage.
/* Note that the STREAMLINE function should create arcs that are all
/*pointing downstream.
%covname% = streamline( lnk, fdr, grid-code, # )
/* For zones defined by the link grid, assign the maximum value of
/* flowaccumulation
/* in that zone to each cell in that zone.
znv = zonalmax ( lnk, fac )
/* Identify outlets as cells with the highest flowaccumulation in a
/* given stream reach.
out = con ( znv == fac, lnk )
&if [exists lnk -grid] &then
  kill lnk all
&if [exists znv -grid] &then
  kill znv all
/* Delineate watersheds
wsh = watershed ( fdr, out )
&if [exists out -grid] &then
  kill out all
/* Convert watershed grids to watershed polygons
%wshname% = gridpoly ( wsh )
/* Quit grid
quit
build %wshname% line
&if [exists wsh -grid] &then
  kill wsh all
&sys mv arc.aml aarc.aml
quit
&return
```

APPENDIX E: INLAND CATCHMENT AML

```
/* Program: fp.aml
/* Author: Francisco Olivera
/* Date: April 16, 1995
/* CRWR J.J.Pickle Research Center
/*
/* Input: dem <digital elevation model - grid>
/* area <screen input - real variable>
/* depth <screen input - real variable>
/* Output: demplus <corrected digital elevation model - grid>
/* filplus <corrected filled digital elevation model - grid>
/* fdrplus <corrected flow direction - grid>
/* Promt: Arc
/*
/* This aml corrects the DEM by assigning NODATA to the sink cells.
/* Sink cells are the bottom cells of those fillings with area and
/* depth greater than threshold values specified by the user.
/*
************************************************************************
******
grid
/* Screen input
&sv area = [response 'Minimum inland catchment area']
&sv depth = [response 'Minimum inland catchment depth']
&sv threshold = [response 'Threshold area for watershed delineation (in grid
cells)']
/*
************************************************************************
******
/* Write your DEM name in the next line
fp01 = wafr_dem
/*
************************************************************************
******
/* Filling the DEM
fill fp01 fp02
/* Calculating the filled depths
fp03 = fp02 - fp01
kill fp02 all
/* Assigning the value 1 to all the filled cells and 2 elsewhere
fp04 = con(fp03 > 0, 1, 2)
```

```
/* Assigning a label number to each to each pit (filled zone)
fp05 = regiongroup(fp04, #, eight)
kill fp04 all
/* Determining the area of each pit
fp06 = zonalarea(fp05)
/* Determining the depth of each pit
fp07 = zonalmax(fp05, fp03)
kill fp03 all
/* Assigning a label to each inland catchment and the value 0 elsewhere
fp08 = con(fp06 > %area% and fp07 > %depth%, fp05, 0)
kill fp05 all
kill fp06 all
kill fp07 all
/* Assigning the lowest elevation to all cells of each inland catchment
fp09 = zonalmin(fp08, fp01)
/* Assigning the value 0 to the lowest cell of each inland catchment
/* and 1 elsewhere
fp10 = con(fp09 == fp01 and fp08 <> 0, 0, 1)
kill fp08 all
kill fp09 all
/* Assigning NODATA to the lowest cell of each inland catchment
rename fp01 fp11
demplus = fp11 / fp10
kill fp10
kill fp11
/* Delineating streams and watersheds
fill demplus filplus # # fdrplus
facplus = flowaccumulation(fdrplus)
strplus = con(facplus > %threshold%, 1)
lnkplus = streamlink(strplus, fdrplus)
wshplus = watershed(fdrplus, lnkplus)
acsplus = streamline(lnkplus, fdrplus, grid-code)
pcwplus = gridpoly(wshplus)
quit

        &return
```

APPENDIX F: FORTRAN PROGRAM FOR SNOW MELT

```
            program soilbal

            integer cellid(1000),ncells,ndays(12)

            real p(1000,13),netrad(1000,13),stmax(1000)
            real surp(1000,13),evap(1000,13),st(1000,13),dst(1000,13)
            real resvap(1000,13)
            real st_temp,surptot,satur
            real tot_p,tot_sur,tot_ev,avg_st,avg_sat
            real snow(1000,13),sstor(1000), temp(1000,13)
            real melt,mstar
!           integer btype,rctype,method
            character infile*12,outfile1*12,outfile2*12
            logical notconv

            data ndays /31,28,31,30,31,30,31,31,30,31,30,31/

! --------------------
!           open (unit=10,file='fbal.ctl',status='old',err=10000)

!           read (10,*) infile
!           read (10,*) outfile1
!           read (10,*) outfile2
!           read (10,*) ncells
            open (unit=20,file='try1.txt',status='old',err=10010)
!           open (unit=21,file='for1out.txt',status='old',err=10020)
            open (unit=21,file='for1out.txt',status='new',err=10020)
            open (unit=22,file='for1ou2.txt',status='new',err=10030)
        ncells = 1000
!Skip first line and read data from input file
            read (20,*)
            do i=1,ncells
             read(20,*,end=1100) cellid(i),stmax(i),(p(i,j),j=1,12),
            1  (netrad(i,k),k=1,12),(resvap(i,l),l=1,12), (temp(i,k),k=1,12)
             enddo
1100   continue
       ncells = i - 1
            write (5, *) ncells, cellid(345),stmax(345),(p(345,j),j=1,12),
            1  (netrad(345,k),k=1,12),(resvap(345,l),l=1,12), (temp(345,k),k=1,12)

! skip the header line that was created by an Avenue script
!           read(21,*)
! start loop soil water balance calculations
            iter = 0
            do i=1,ncells
                    do j=1,13
                            surp(i,j)=0
```

```
                    evap(i,j)=0
                    snow (I,j)=0
                    st(i,j)=stmax(i)
                enddo
        enddo
! --- loop through all cells
        do i=1,ncells
        notconv=.true.
        k=0
! --- begin budgeting loop for current cell
        do while (notconv.and.(k.le.30))
                k=k+1
                do n=1,12
                    st_temp=st(i,n)
                    surptot=0
        if (i . ge. 563) write (5, *) 'on repart'
        if (i . ge. 563) write (5, *)i
!               --- begin pseudo-daily budgeting
                    do j=1,ndays(n)
        if (i . ge. 563) write (5, *) i, k, n, j
        if (i . ge. 563) write (5, *) st_temp, stmax(i)
                                satur=st_temp/stmax(i)
                                ! if using the traditional method, redefine
                                ! evaporation based on soil moisture extraction
                                ! function


!                               runoff=p(I,n)*satur
                                evval=resvap(i,n)*satur

                                if (temp(i,n) .ge. 2.) then
                                        mstar = 0
                                else
                                        melt = 2.63 + 2.55*temp(i,n) +
        1                                               0.0912*temp(i,n)*p(i,n)
                                        sstor(i+1) = sstor(i) + snow(i,n) - melt
                                        if (sstor(i+1) .lt. 0 ) then
                                                sstor(i+1) = 0
                                        end if
                                end if

                                if (melt .gt. 0) then
                                runoff= melt*satur
                                else
                                        runoff = 0.
                                end if
                                runoff=runoff + p(I,n)*satur
```

```
                                        st_temp=st_temp+p(i,n)/ndays(n)-evval/ndays(n)-
runoff
          1                                                    - mstar

                                        if (st_temp.lt.0) then
                                                st_temp = 0.01
                                          endif

                                        if (st_temp.gt.stmax(i)) then
                                                dsurp=st_temp-stmax(i)
                                                surptot=surptot+dsurp
                                                st_temp=stmax(i)
                                        endif
                                surptot=surptot+runoff
                                enddo
        !               --- finished loop through days

        !           --- Compute monthly totals

                                st(i,n+1)=st_temp
                                surp(i,n)=surptot

                                if (n.gt.1) then
                                        dst(i,n)=st(i,n+1)-st(i,n)
                                          evap(i,n)=p(i,n)-surp(i,n)-dst(i,n)
                                endif
        !           --- budgeting completed
                        enddo

        !           --- test for convergence

                        diff=st(i,1)-st(i,13)
                        if (abs(diff).lt.0.1) then
        !           write (5, *) 'notconv'
                          notconv=.false.
                    endif

        !           --- alter the initial soil moisture guess
                        st(i,1)=st(i,13)

        !           --- finished balancing for one cell

                    enddo
        !            write (5, *), i, k
                    dst(i,1)=st(i,1)-st(i,12)
                    evap(i,1)=p(i,1)-surp(i,1)-dst(i,1)
        !            write (5, *) dst(i,1), evap(i,1)

                    if (k.gt.30) then
                        write(*,*) 'Convergence not achieved after 30 iterations.'
```

```
            endif

! --- end of loop through cells
            enddo

! --- check average cell surplus for Texas
! if the average surplus is within 2 mm, then quit
! otherwise, modify the runoff function
            stot=0
            do i=1,ncells
              do j = 1,12
                stot = stot + surp(i,j)
              enddo
            enddo

            avgsur = stot/ncells

! end the loop of repeating the calculations until total
! surplus in Texas converges

            iter = iter + 1
!enddo
!write summarized results to a file

            write(22,*) 'cellid,tot_p,tot_sur,tot_ev,avg_st,avg_sat'
            do i=1,ncells
               tot_p=0
                     tot_sur=0
                     tot_ev=0
                     avg_st=0
                     avg_sat=0
               do j=1,12
                       tot_p=tot_p+p(i,j)
                       tot_sur=tot_sur+surp(i,j)
                       tot_ev=tot_ev+evap(i,j)
                       avg_st=avg_st+st(i,j)*ndays(j)/365
               enddo
                     avg_sat=avg_st/stmax(i)
                     write(22,9100) cellid(i),tot_p,tot_sur,tot_ev,avg_st,avg_sat
            enddo
            do i=1,ncells
            write (5,*) i
                              write(21,9000) cellid(i),(surp(i,j),j=1,12),
            1                         (evap(i,j),j=1,12),(st(i,j),j=1,12)
!                             write(21,9000) cellid(i),(evap(i,j),j=1,12)
!           1                         (evap(i,j),j=1,12),(st(i,j),j=1,12)
            enddo

            write(*,*) 'Water budget complete.'
! ---------write(*,*) AA,BB,CC,DD
```

```
            write(*,*) 'Avg. Surplus=', avgsur, iter
            stop

9000   format(i6,',',35(f7.2,','),f7.2)
9100   format(i6,',',4(f7.2,','),f6.4)

!10000 write(*,*) 'Could not open control file.'
!           stop

10010 write(*,*) 'Could not open input file.'
            stop

10020 write(*,*) 'Could not open output file1.'
10030 write(*,*) 'Could not open output file2.'
            stop

! --- end of program
            end
```

Bibliography

Aizen V., Aizen E., Nesterov, V., Sexton, D. A Study of Glacial Runoff Regime in Central Tien Shan During 1989-1990, Journal of Glaciology and Gerocryology, Volume 15, No3, Sept, 1993

Aizen V., Aizen E., Melack J, Dozier J. Precipitation,melt and runoff in the Northern Tieen Shan. Personal Communiation, 1996a

Aizen V., Aizen E., Melack J. Precipitation,melt and runoff in the Northern Tieen Shan. Personal Communiation, 1996b

Anderson, E.A. A Point Energy and Mass Balance Model of Snow Cover. NOAA Technical Report NWS 19, Department of Commerce, Washington D.C, 1976.

Anderson, Robert C. Environmental Damage Assesment of the Aral Sea Disaster. USAID, Kazakstan, 1997.

ArcAtlas CD ROM, Environmental Systems Research Institute, 1997.

Asia Plus, April 1997. http://www.internews.ras.ru/ASIA-PLUS/bulletin_22/alumni.html

BISNIS, Business Information Service for the Newly Independent States September 1997. http://www.itaiep.doc.gov/bisnis/country/cntasia.htm

Bortnik, V.N, Kuksa V.I, Tsytsarin, A.G. “Present Status and Possible Future of the Aral Sea”, Post-Soviet Geography, Volume 33, 1992.

Brubaker, K.L., Rango, A. "Response of Snowmelt Hydrology to Climate Change", Water, Air and Soil Pollution 90: 335-343, 1996.

Brubaker, K.L., Rango A., Kustas W., " Incorporating Radiation Inputs into the Snowmelt Program Runoff", Hydrological Processes, Volume 10, 1329-1343, 1996.

Cheterian, Vicken. "Les Ambitions Contrariees de l'Ouzbekistan". Le Monde Diplomatique, July 1997, SA Le Monde, Paris.

DEV, Devlopement and Environment Foundation. http://ntserver.cis.lead.org/aral/enviro.htm, 1997.

Digital Atlas of the World Water Balance CD ROM, May 1997. Center for Research in Water Resources, University of Texas at Austin.

Digital Chart of the World CD ROM, Environmental Systems Research Institute, 1996.

Draper, Stephen. "International Duties and Obligations for Transboundary Water Sharing". Journal of Water Resources Planning and Management, Nov/Dec 1997.

EU Tacis Program, ArcView Coverages. Stuart Gunn, Personal Communication, 1997.

FAO, Food and Agriculture Organization. http://www.fao.org/news/1997/970104-e.htm, 1997.

Gleason, Gregory. The Struggle for Control over Water in Central Asia. Report on the USSR, June 21, 1991.

Hoogeven, Jippe. Regional Water Balance Through GIS. Personal Communication, 1997.

Info Mine, June 1997. http://www.info-mine.com/central.asia/doingbusiness.html

Kazakstan, Welcome to Kazakstan, August 1997 . http://www.kz/eng/kzinfo/kz3.html

Keith J.E., McKinney, D.C. “Options Analysis of the Operation of the Toktogul Reservoir”, Environmental Policy and Technology Project, August 1997.

Klotzli, Stephan. The Water and Soil Crisis in Central Asia - a Source for Future Conflicts ?, http://www.fsk.ethz.ch/encop/11/en11-con.htm, 1994.

Kygyzstan, Business and Tourist Directory, February 1997. http://ourworld.compuserve.com/homepages/dite

Naby, Eden. "The Emerging Central Asia: Ethnic and Religious Factions". University Press of Florida, 1994.

Maidment, David. R. Handbook of Hydrology. McGraw Hill, 1993.

Mesbahi, Mohiaddin. Central Asia and the Caucasus after the Soviet Union. University Press of Florida, 1994.

MFA: Ministry of Turkish Office, April 1997. http://www.mfa.gov.tr/GRUPF/water/annex/Annex2.HTM

Mobil, Mobil News and View, August 1997. http://www.mobil.com/this/news/opeds

Murzayev, E.M. “Research on the Aral Sea and Aral Region”, Post-Soviet Geography, Volume 33, 1992.

NPD, National Performance of Dams Program, February 1997. http://blume.stanford.edu/~npdp/npdp/damhigh.html

Olivera, Francisco. Inland Catchments, 1997. http://www.ce.utexas.edu/prof/olivera

OneWorld. http://www.oneworld.org/patp/pap_aral.html, 1997.

Reed, Seann ,1997. http://www.ce.utexas.edu/prof/maidment gishydro/seann/seann.htm

Roy, Olivier, La Nouvelle Asie Centrale ou la Fabrication des Nations.Editions du Seuil, Paris, 1997.

Sangonet, Convention on Law of the Non-navigational Uses of International Watercourses(July1997)http://wn.apc.org/afwater/UN%20Convention %2097.htm

UN, United Nations, gopher://gopher.un.org/00/esc/c7/1996/96--3.en, 1997, 1997.

UNEP, The Aral Sea: A Diagnostic Study for the Development of an Action Plan for the Conservation of the Aral Sea, 1991.

UNHDP United Nations Human Development Program , 1996 . http://www.undp.org/undp/rbec/nhdr/1996/summary

USGS, United States Geological Survey June, 1997. http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html

Whitlock et al., "First Global WCRP Shortwave Surface Radiation Budget Data Set," Bull. Amer. Meteor. Soc., 76, 6, 905-922, 1995.

Willmott, C.J., C.M. Rowe, and Y. Mintz, "Climatology of the Terrestrial Seasonal Water Cycle," Journal of Climatology, 5, 589-606, 1985.

World Bank, Project 1.1, Aral Sea Program Technical Paper Series, April 1996.

World Bank, Project 1.1, Aral Sea Program Technical Paper Series, Developing a Regional Water Management Strategy, August 1996.

Vita

Sandra Akmansoy was born in Paris, France on May 29, 1974, the daughter of Anne-Marie Delorme and Fazli Cemil Akmansoy. She lived in Paris until she was nine years old at which time she moved with her family to Houston, Texas. She graduated high school from Northwest Academy in Houston in May 1991. She earned her Bachelor's Degree of Science in Civil Engineering at the University of Texas at Austin in May 1996. She completed her Master's Degree of Science in Civil Engineering in December 1997.

Permanent address: 115 rue de Vaugirard
Paris 75015 France

This thesis was typed by the author.