SUSTAINABLE WATER MANAGEMENT IN TURKMENISTAN: CHALLENGES AND SOLUTIONS

MASTER THESIS

Ernst-Moritz-Arndt University of Greifswald
Landscape Ecology and Nature Conservation
Master of Science Program

Amangul Ovezberdyyeva
Greifswald, November 2009

Supervisors:
Prof. Dr. Konrad Ott (Environment Ethics)
Dr. Niels Thevs (Geobotany and Landscape Ecology)

Head of the Institute of Botany and Landscape Ecology, Greifswald University:
Prof. Dr. Martin Schnittler

Thesis submitted to the Botany and Landscape Ecology Institute of Ernst-Moritz-Arndt University of Greifswald in partial fulfillment of the requirements for the degree of Master of Science in Landscape Ecology and Nature Conservation.

This document describes work undertaken as part of a programme of study at the Botany and Landscape Ecology Institute of Ernst-Moritz-Arndt University of Greifswald. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the institute.

Acknowledgements

My supervisor Prof. Dr. Ott deserves great thanks for his support during the preparation for this thesis and for his supervision during the work. Great thanks also deserve my supervisor Dr. Thevs for his advices and supervision.

I would also like to thank all colleagues from the Amu Darya Nature Reserve for arranging my field work in Lebap Velayat.

Great thank deserve the Michael Succow Foundation that granted my two year’s study with Eva-Klien Scholarship.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Turkmenistan is an arid country with a huge territory of 491,200 square km. In the north, Turkmenistan borders with Kazakhstan, in the east – with Uzbekistan, in the south – with Iran and Afghanistan, in the west – across Caspian Sea with Azerbaijan (Fig. 1). Most of this territory (80%) is covered with the largest desert in the Central Asia – the Karakum Desert. The water resources therefore are vital for the people living there and a limiting factor for the development of the country. Given the constancy of water resources and the rapidly growing population in the country, the annual water availability per capita decreased by 50% during the last 35 years, dropping to 3.000 m^3 in 2004 (Stanchin and Lerman 2005).

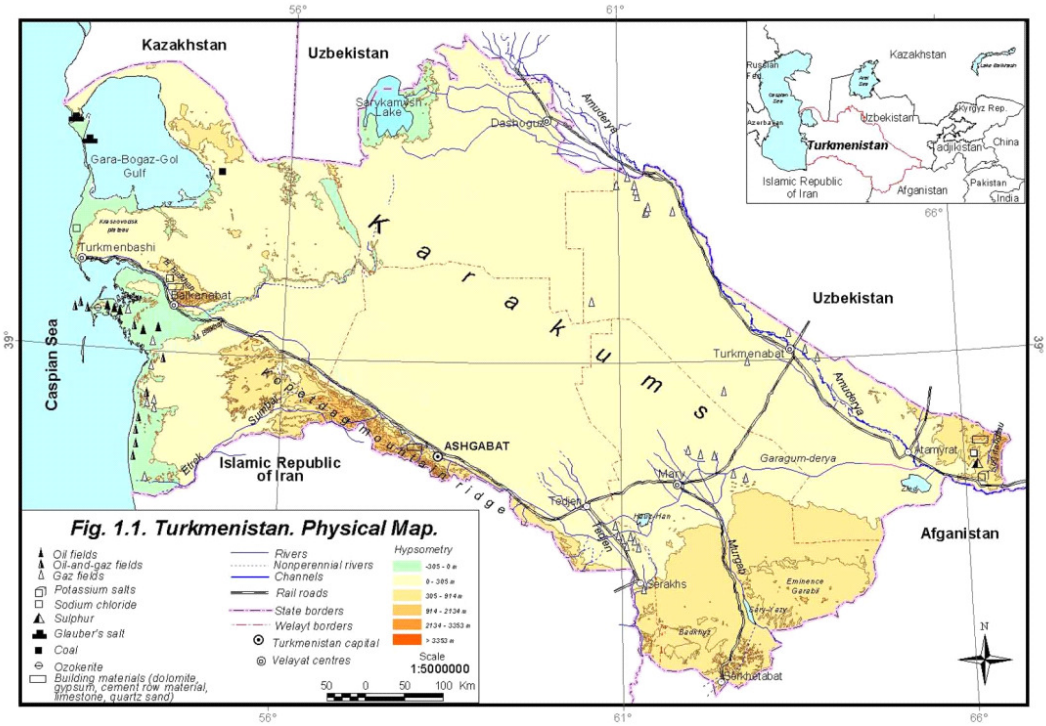


Figure1. Physical map of Turkmenistan (Rajapov et al. 2002).

The main source of water for all agricultural and non-agricultural uses in Turkmenistan is the Amu Darya River which makes up 88% of all surface water resources in Turkmenistan. About 744 km of the river flows on the territory of Turkmenistan, mostly through the Lebap Velayat (administrative province) and consequently reaches the Aral basin in the north. Therefore, the Lebap Velayat is relatively rich compared to other regions of the country with respect to the water resources and its distinctive biodiversity. It also has major significance for the country's economy, especially for agriculture.

Despite its aridity Turkmenistan has a long history of agriculture and always depended on irrigation. Agriculture is the main water user in Turkmenistan, consuming 95% of the available resources. The emphasis on the expansion of cotton production during the Soviet Union period (1924-1990) and the strategy of food self-sufficiency aggressively implemented since 1992 have led to accelerated growth of irrigated areas, which increased by nearly 4 times in the last 40 years, reaching 2.3 million hectares. Almost half of this area – 1 million hectares – has been added during the 15 years since independence (Stanchin and Lerman 2005). Today agriculture remains the main source of employment, export earnings and livelihood for the population of Turkmenistan.

Tugai (riparian) forests and reed beds distributed along the Amu Darya Rivers have been severely degraded due to logging and conversion into agricultural land. The reed beds have been degraded due to

overgrazing and partly due to conversion into agricultural land. Furthermore, both ecosystems suffer from reduced river runoffs (Thevs et al. 2007). The most productive and diverse ecosystems of Turkmenistan are found in the mountains and along the Amu Darya River, i.e. riparian forests distributed in a mosaic together with reed and shrub vegetation (Rajapov et al. 2002). The riparian forests are the most productive natural ecosystems of Turkmenistan. At present, the over-all area of tugai forests in Turkmenistan is 38 800 hectares, including the territory in the Amu Darya Reserve which is 5 000 hectares (Gladyshev 1992). The unique riparian vegetation is considered as disappearing landscape of high conservation value (Marochkina 2006; Rustamov and Rustamov 2007). The last research on tugai forests was conducted more than 15 years ago. Now there are no specialists in Turkmenistan dealing with tugai vegetation and the current state of tugai forests is indeterminate.

The Amu Darya River is one of the water sources for the Aral Sea. Large-scale programs of land development implemented in the Aral Sea Basin resulted in a twofold increase of both irrigated areas and draw off discharge. In the late 1980s, the mighty Amu Darya failed to reach the Aral Sea. Annual negative profits in the region are around some billion dollars due to changes of climate and hydro chemical characteristics of water bodies, a reduction of fishing in the Aral Sea, degradation of more than 4 million hectares of land and deterioration of biodiversity (Kulmatov 2007). Growing demand for irrigation water, high levels of water pollution, frequent droughts and widespread land degradation are among the key water-related issues for the region that already threaten human development and security. In Turkmenistan, the increase of human pressure on rivers and on fresh ground water, as well as the degradation of the environment in some irrigation areas have become critical issues requiring urgent consideration in view of safeguarding and rational use of water resources. These issues are becoming very important due to the changing climate and water supply. Climate change is anticipated to alter the hydrological cycle and is unlikely to relieve the limitations placed by water scarcity upon the region (Glantz 2003).

Additionally to the above mentioned, it is anticipated that Afghanistan will claim Amu Darya river water in order to revive its agriculture sector. Then maybe, Turkmenistan as middle stream country would have even less water and downstream Uzbekistan would not receive any. The Amu Darya River crosses five countries and there should be a fair transboundary solution for the use of its water, in line with international laws. Otherwise political conflicts can take place. The issue of fair distribution of Amu Darya River water is quite complex and needs long discussions. Within the given thesis I can not discuss all aspects because the situation is constantly changing. We are not able to predict developments in Afghanistan and other neighboring countries that might take place in the following five years.

1.1.Objectives

The Lebap Velayat is the place where the largest river of the Central Asia and the unique Tugai ecosystems are located in Turkmenistan. Both of these ecosystems play a significant role for the humans, their economic activity and biodiversity. Thus, the middle stream of Amu Darya River stretched within Lebap Velayat was selected for this study in order to search for a sustainable solution to water management in Turkmenistan. The aim was to gain insight into the complexity of water and land use and socioeconomic issues and investigate what kind of agriculture, what kind of irrigation, what kind of crop will be truly sustainable in the future of the Amu Darya region and the conservation of natural ecosystems.

Thus, this study addresses the following research aims:

- to investigate the land and water use history from the pre Soviet Union period (before 1890) up to now,
- to define main driving forces for the status of environment of the study areas and describe their implications for the environment and natural resources,
- to rise issues regarding water scarcity problems and inadequate water management and,
- to give suggestions for sustainable water management and theoretical ideas for its realization.

The study area is described with regard to its relief, geology, climate, hydrology, soils, biodiversity and social aspects (Chapter 2). This part also includes a land cover map of the study area based on the classification of satellite images. The methods employed are described in Chapter 3. The results and the discussion of the results are expounded in chapters 4 and 5. The results consist of three sections, the first of which focuses on the history of land use, the second on the interview data and the last one on the environmental situation of the study area. The discussion closes with conclusions and suggestions for the conservation of the environment with the main focus on water resources.

The current data on the Tugai vegetation were collected for mapping of the study area for Practical Project. The fieldwork for this purpose was carried out in Lebap Velayat between Turkmenabad city and Amu Darya Nature Reserve (Kabakly plot) in March 2008. The up-to-date knowledge of the environmental situation and land use practice in Lepab Velayat was gained through interviews with national experts and local people. The interviews were conducted in the capital of the country and in Lebap Velayat in March-April 2009.

This paper touches critical topics like sustainable agriculture, water management and environment related issues. It gives analytical and theoretical perspectives. Therefore, it discusses highly relevant and important issues for Turkmenistan today. The paper will be distributed for consideration among specialists, environmentalists and political leaders dealing with water management issues.

2. STUDY AREA

2.1. Geographic Position

Turkmenistan is divided into five administrative provinces (velayats) – Akhal, Balkan, Mary, Lebap and Dashogus velayats. Our study area in the middle reaches of the Amu Darya River is located within the Lebap Velayat. The Lebap Velayat is in the northeast of the country, bordering Uzbekistan along the Amu Darya. On the southeast, the velayat borders with Afghanistan where the Amu Darya River flows from Afghanistan into Turkmenistan. From both sides, the Amu Darya River is influenced by deserts, on the west side there is the Karakum Desert and on the east side Sundukly and Kyzyl Kum Desert (Fig.2). On the north, the Amu Darya River crosses the border and enters Uzbekistan. The capital of the Lebap Velayat is Turkmenabat (formerly named Chardzou). It has an area of 93,730 square km, and a population of 1,334,500 people (National Institute of State Statistics 2005).

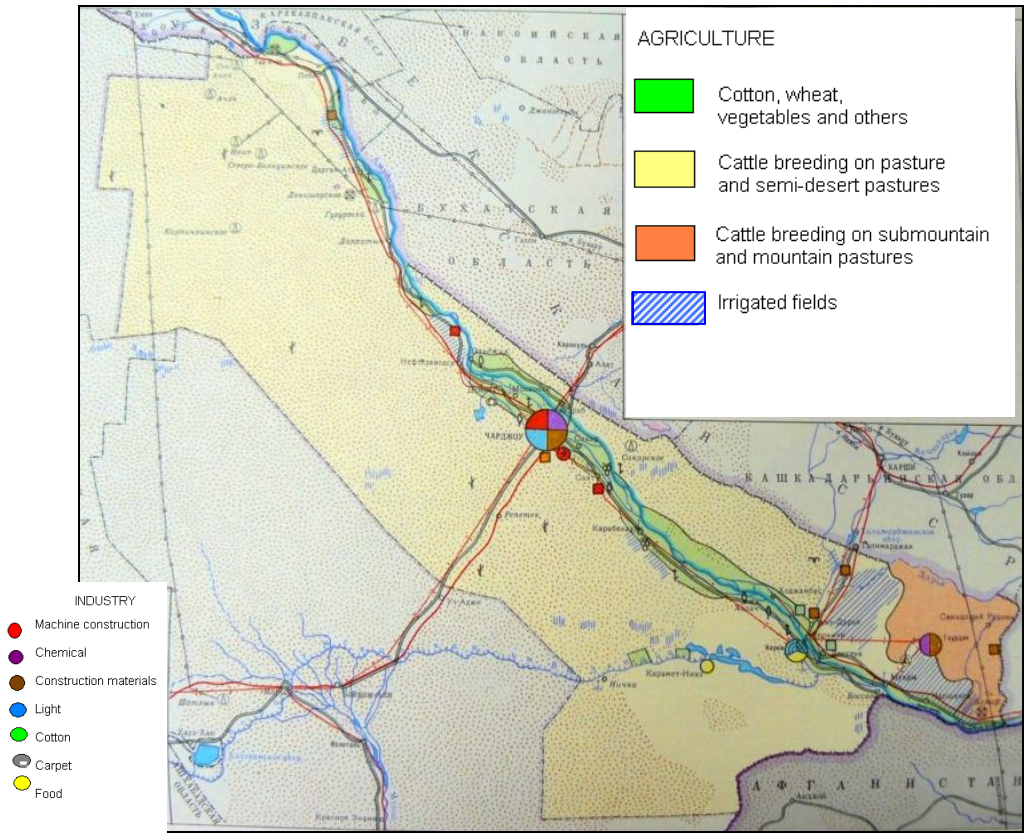


Figure 2. Administrative map of Lebap Velayat (Encyclopedia of TSSR 1984).

The investigated area contains the Amu Darya State Reserve, Repetek Biosphere Reserve and the Köýtendag State Reserve, which includes Turkmenistan's highest mountain, Aýrybaba (3137 meters). Amu Darya State Reserve created along the river consists of Kabakly, Gerelde and Nargiz plots. There, the unique Tugai forests are preserved. We focus on Lebap Velayat because non-sustainable land-use and over-exploitation of water resources led to many ecological problems. Some consequences were the Aral Sea disaster and strong degradation of Tugai vegetation on the Amu Darya River floodplain.

The study area situated along the Amu Darya River valley encompasses almost the whole middle course of the river and some part of its delta. Therefore, all information about soil, geomorphology, climate and biodiversity of the study area is inseparably linked with the region of the Amu Darya River.

2.2. Relief and geology

On the left bank of the Amu Darya River the Karakum Desert is located. This desert is a sandy overgrown plain of alluvial thickness (200-800 m) of grey Karakum Desert. According to surface formation time, material origin and relief adjoining to Amu Darya, the Karakum is divided into the following geomorphological areas: East Karakum (matted, partly sand-dunes places with hollows and group Neogene outlier); Dzhinlikum Karakum (20 km strip wavy-slopping Middle Quaternary plains with the condensed sandy surface with spots of fine ridge and middle hilly sands and small takyrs) and; Zaunguz Karakum (a plateau with large sandy ridges, in the north with the Pitnjaksk uplands) (Ashirova 1964). The right bank of Amu Darya is occupied with Sundukly Desert. The Pliocene-Quaternary plateau consists of condensed sandy-loamy and loamy sediments. Eolian sands laid over a plateau form sub-meridian and weak-fixed ridge relief sometimes partitioned up to hilly type. The bottoms of deflationary depressions now are filled with the former saline soils. The modern Amu Darya valley is formed on upper and lower Quaternary continental sediments consisting of dense sandstones and clays. With removal from an oasis to periphery more sands prevail in ancient and modern Amu Darya sediments (Marachkina 2006).

In the geological respect, the modern Amu Darya river valley settles down in an enormous depression which was already outlined in the Mesozoic era, but was eventually formed considerably later due to tectonic processes at the end of the Tertiary and the beginning Quaternary period. These tectonic transformations had created a number of anticlinal folds in a cross-section direction of Amu Darya. The specified folds further played a role for the natural dams holding river run-off and wandering waters, filling lake falls. The river bank throughout the extent of its flat part is formed by sandy-clay alluvion (fluvial sediments). On the low banks, which are filled with high waters, these sediments form surface deposits which may be more clay or more sandy. Raised river banks confined mainly to radical (basic) ridges, are made up of rocks of various lithological structure. These rocks destroyed nowadays by the Amu Darya, represents an alluvion formation source. Their structure consists of yellow packed sand or friable sandstones, interstratifying with chalky clay (marl) of various character. The Amu Darya River is characterized by a very dynamic flow of water, the river bed is highly variable and frequently changes its course; banks are washed out in one place and deposited in another (Rustamov and Rustamow 2007).

Based on the satellite image classification, a land cover map was developed for the Practical Project in 2008. The total classification area was 15090.5 km², including the study area (Fig. 3). The map shows the distribution of different ecosystems along the study area and two parts of Amu Darya Nature Reserve – Gabakly and Nargiz which are outlined with a yellow line.

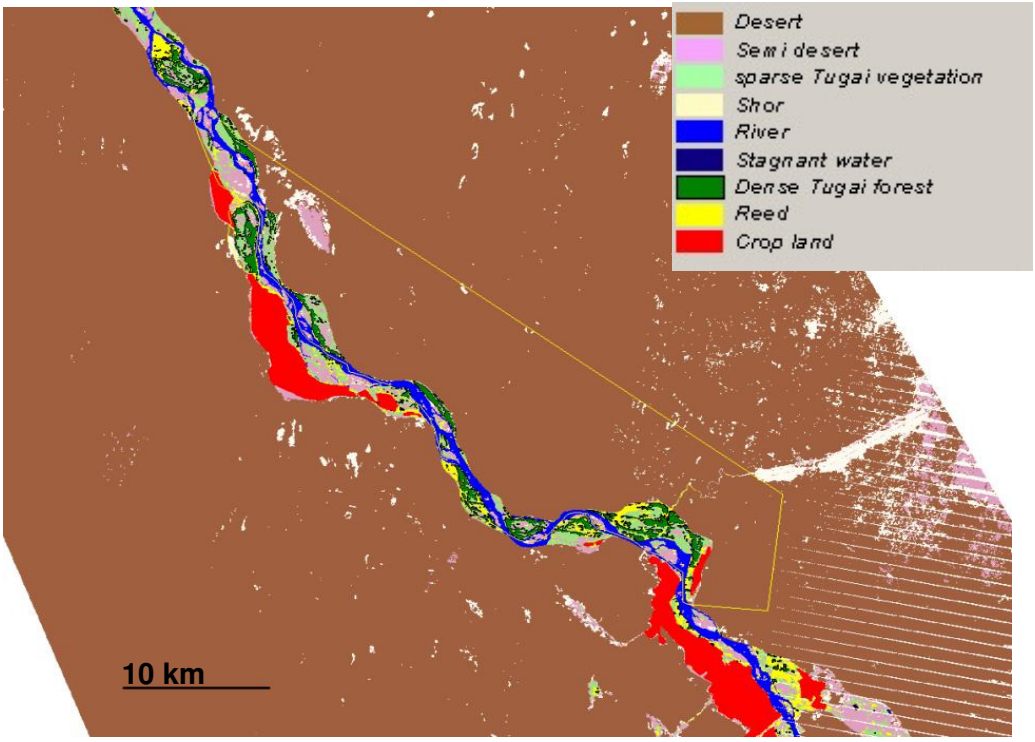


Figure 3. Land cover map derived from satellite image classification (Practical Project 2008).

The satellite image classification enabled to calculate areas covered by the different ecosystems (land cover classes) (Table 1). There is an unclassified area within the study area which was not covered by the Landsat images due to strips.

Table 1. Land cover classes (Practical Project 2008)

Land cover classes	Area, km²	%
Desert vegetation (less than 10 %)	12114.4	80.28
Shor (salty land)	663.8	4.40
Unclassified area	643.9	4.27
Arable lands	634.2	4.20
Semidesert (vegetation coverage 10-25%)	303.7	2.01
Sparse Tugai (vegetation coverage 25-50%)	174.8	1.16
River	169.0	1.12
Reed	141.2	0.94
Stagnant water	128.7	0.85
Dense forest	116.8	0.77
Total	*15090.5*	*100*

It is shown that mostly the classification area is covered desert vegetation and Shor where the vegetation cover is less that 10 percent of land and sometime it even absent. Many areas are also occupied with irrigation fields where local people plant cotton, wheat, rice, vegetables etc. Dense forests occupy only 0.77 percent and are situated mainly within protected areas.

2.3. Soils

The parent materials of the soils in the study area are fluvial or eolian sediments. According to the FAO soil classificaton (Driessen and Dudal 1991) the relevant soil types in the study area are: Fluvisols, Gleysols, Solonchak, Arenosols, and Anthrosols. The former three are characterized respectively by fluvic, gleyic, and salic properties as diagnostic indicators. Arenosols are soils which have developed in the eolian sediments. Anthrosols are the soils changed by agriculture. They are characterized by accumulative agro irrigational sediment, deep humus horizon. The anthropogenic contribution such as every possible fertilizer, regular irrigation has resulted in the formation of such soils. These soils are used for irrigation agriculture.

- **Meadow, meadow swampy soil** (Fluvisol, Gleysol) - Accumulation of organic matter from litter of herbaceous and woody plants; gleyic properties in the subsoil. Parent material consists of fluvial sediments. Degree of salinity varies from slight to severe. Tugai vegetation is common here. These soils can be reclaimed only by construction of drainage. Floodplains and alluvial fans along the Amu Darya (Kharin 2002).
- **Takyr like soil and takyr** (Takyric Solonchak, Solonchak) – Takyr like soils formed by fluvial sediments with a surface layer of fine materials from former water body. These soils are medium or strongly saline, the content of humus is low – about 0.5-1.0%. These soils locate on ancient delta plains of the Amu Darya and widely used in irrigation agriculture. Takyr is a specific soil formation in Central Asian deserts. They are usually located in shallow depressions. The

thickness of soil profiles is 15-25 cm. It is very difficult to reclaim these soils because of their heavy mechanical composition, high salinity and low humus content.

- **Gray brown soils** (Arenosol) - Formation on fine sandy loam and on sandy deposits underlain by limestone and pebble diluvium. Soil material usually contains much crystal gypsum ground water are usually saline, their depth is more than 20 m the content of carbonate is very high, the humus content is very low, about 0.5%. These soils distributed on fluvial sand and sand dune areas.
- **Irrigated soil** (Anthrosol) - Formation of a horizon with gleyic properties due to irrigation, partly secondary salinization through inappropriate irrigation. These soils are distributed in areas influenced by irrigation.

2.4. Hydrology

The main water resource of the study area is the Amu Darya River which makes up 88% of all surface water resources in Turkmenistan (Fig. 5). The Amu Darya River is the largest river in Central Asia. It is formed by the Pyanj River (Afghanistan) and the Vaksh River (Tajikistan). Its length is 1415 km (Schults 1965), and up to 726 km of river flows within Lebap Velayat. Here the water flow is quite permanent while in the lower reaches occurs occasionally only, due to heavy irrigation. Finally, the river reaches the Aral basin in the north. The river's drainage basin totals 534,739 km² in area, providing a mean discharge of around 97.4 km^3 of water per year.

On physical-geographical conditions the river basin can be divided into two sharply differing parts. The top east part, which is actually a river reservoir, represents typical highland, with average heights about 2500 m. The western, flat part of Amu Darya river basin is an area of discharges or an idle part of basin (Ashirova 1971).

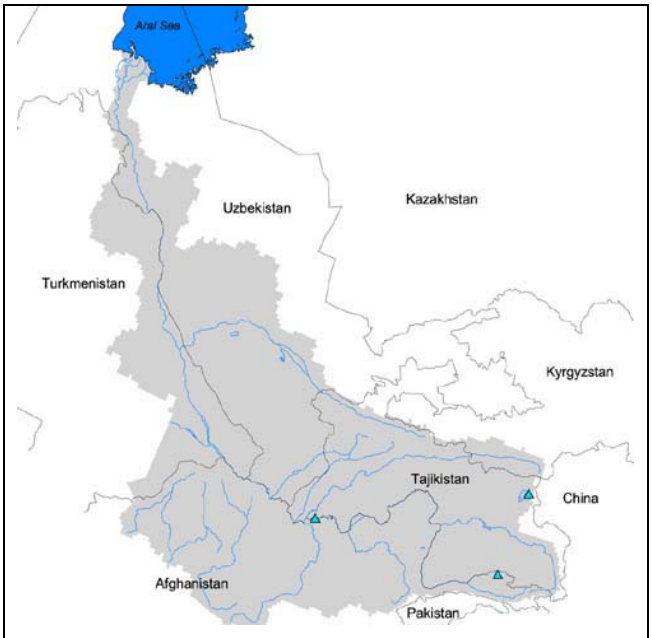


Figure 4. Amu Darya River watershed (www.wikipedia.org).

The Amu Darya is a Transboundary River and its water is used by many other countries (Fig. 4). Water from the Amu Darya was divided annually in the following way: Uzbekistan 29.6 km^3, Turkmenistan 22 km^3, Tajikistan 9.5 km^3, and Afghanistan 2 km^3. The Amu Darya has two water reservoirs, the Nurek reservoir upstream in Tajikistan and the Tuyamuyun reservoir downstream in Uzbekistan (Glantz 2003). Within Turkmenistan from Amu Darya branches three large canals – Karakum, Karshinsky and Amu-Bukhara. Between Atamyrat and Eldjik gorge the width of Amu Darya modern floodplain valley fluctuates within 4-25 km, in its lower current – 3-9 km.

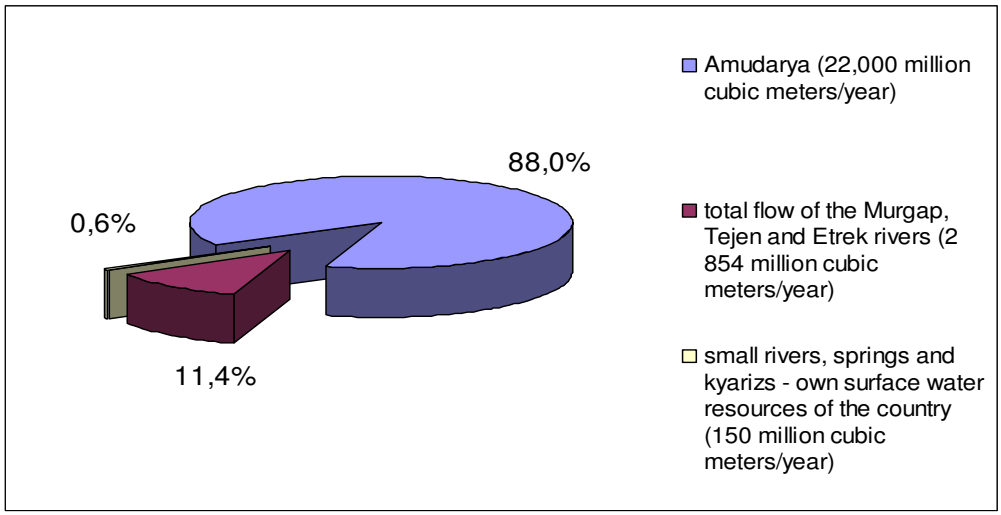


Figure 5. River water resources of Turkmenistan (Rajapov et al. 2002).

Karakum Canal is the largest hydrotechnical construction in the world (1380 km long) and has paramount importance to satisfy the water needs of all the Velayat s of Turkmenistan, except Dashoguz Velayat. This artificial river, built for the purpose of irrigation, supplies water to nearly all large industrial centers of the country: Ashgabat, Mary, Balkanabat, Turkmenbashy. In Turkmenistan the productive forces have undergone dramatic changes owing to this man-made Karakum Canal that unites the Amu Darya, Murgab and Tejen rivers into the integrated water management system.

2.4.1. Amu Darya river regime

For Amu Darya middle and down stream the raised location of the river bed over a radical bank is quite typical. This can be explained by the riverbed rising due to its regular silting which amounts 13 mm per year (Altunin 1951). In this connection, during floods the river water washes away its modern bank. After floods, water fills the lowered places, forming temporary lakes. On plain areas these periodic floods and water stagnations influence water table dynamics and natural and cultural vegetation development.

The riverbed, being exposed by strong deformation, wanders within a flood plain; waters wash away left and right banks. The greatest bank washouts occur during water recession. According to hydrologists the river cross-section during the year can reach 200-400 m, and average long-term about 100 m.

Amu Darya River is fed by snow and glacier melt water as well as precipitation mainly in summer. Therefore, annual runoff is concentrated in the spring-summer seasons. In a runoff regime of Amu Darya River law distribution and dynamic of ground water play an important role. As a rule, groundwater reflects fluctuations of water horizons in the river. Amu Darya River is a loosing stream i.e. reworks its riverbed. The regime of ground waters is defined often by character of development and change of vegetative cover which is of great importance for agriculture. During strong floods the river courses may break out of their beds and form new courses, and then the entire river system can be changed. Each flood carries huge loads of sediments into the inland delta in the middle reaches of the Amu Darya River. Together with the climate, it builds up a peculiarity of a vegetative cover of the river valley (Ashirova 1971).

2.5. Climate

Our study area lies in the zone of warm and arid continental climate like the whole territory of the country. Since the study area occupies quite a large territory from south to north there are some climatic differences. Thus, for better understanding some ecological processes the territory can be further divided into following climatic areas: Lower Amu Darya, Northern Karakum, Southern Karakum and Southeast Karakum (Orlovsky and Volosyuk 1974). The meteorological parameters of these areas slightly differ from each other (Table 2).

The Lower Amu Darya climatic zone covers the irrigated downstream region on the north of the study area. This zone is the coldest plain part of the Turkmenistan. The Northern Karakum climatic zone encompasses the northern part of Amu Darya valley from Dargan-Ata till crossing border with Uzbekistan. This zone is comparatively cold due to its openness to the north and consequently a penetration of cold air masses. The Southern Karakum climatic zone is divided into two parts – Lower Karakum zone which is located between the west side of the Amu Darya River and Sundukly zone on the east side of the river. This zone includes many industrial cities such as Turkmenabad, Kerki, Seidy. It is the warmest part of the Amu Darya river basin which is characterized by a high mean temperature and relative warm winter (Fig.6).

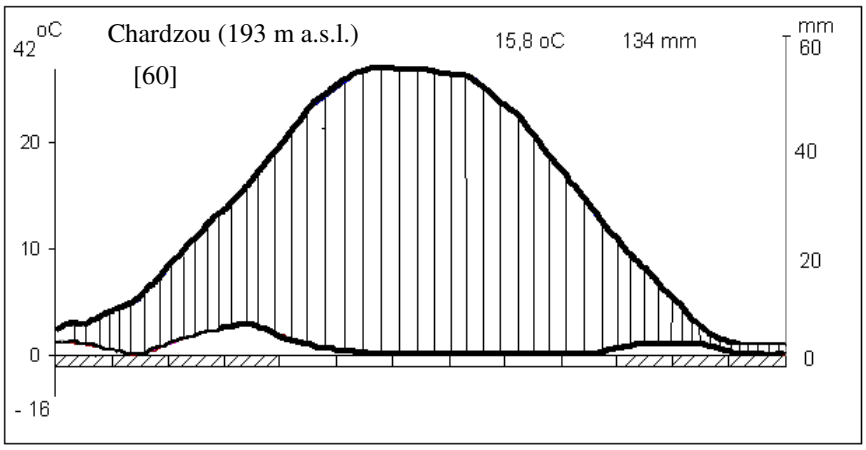


Figure 6. Climate diagram of Turkmenabad (Chardzou) according to www.weatherbase.com.

The Southeast Karakum climatic zone covers the south east part of Lebap Velayat and includes the Karakum Canal region. A specific feature of this region is the presence of "Afghans" - the strong gusty winds bearing a large amount of a dust. "Afghans" happen in a warm and cold season, and in the second case together with dust snowfalls are possible.

Table 2. Climatic parameters of Amu Darya River valley (Orlovsky and Volosyuk 1974)

Parameters	Lower Amu Darya	Northern Karakum	Southern Karakum	Southeast Karakum
Mid-annual air temperatures, ^{o}C	12	12,3	15,8	16,8
Average temperature of the coldest month, ^{o}C	-6	- 5.2	- 0.2	+20
Average temperature of the warmest month, ^{o}C	+27	+ 28	+ 31	+ 31
Temperatures fluctuation, ^{o}C			31	29
Frost free period, days	187-200	200	230	230
Days with temperature above +10 ^{o}C, days	196	210		250
The sums of effective temperatures, ^{o}C	4000-4300	4300	5300	5800

Annual precipitation, mm/y	76-90	100	134	204
Evaporation, mm		1700	2248	2155
Relative humidity:				
Minimum, %	38-42	36	28	38
Maximum, %	77-79	79	77	76
Solar light, an hour		3000	many	3100
Max temperature, ^{o}C	+44-45	+ 45	+ 46 (Kerki)	+ 47
Min temperature, ^{o}C	-36	- 32	- 25	- 31
Snow cover, days per year		10-15	10-13	15

2.6. Biodiversity

2.6.1. Flora

The riparian forests of Central Asia are called Tugai forests (Tian, 1991). The whole riparian vegetation is called Tugai vegetation (Ogar, 2003). The Tugai vegetation is composed of phreatophytic plants, i.e. plants which contact the groundwater in order to take up water and thus survive in the arid environment (Smith et al., 1998; Gries et al., 2003).

From a global perspective, Tugai forests are a unique and threatened flood plain ecosystem. They provide ecological benefits such as biomass and carbon accumulation, due to their high productivity, prevent desertification, and cool the local climate. The developed root systems of the plants strengthen riverbanks, preventing their erosion and landslips (Thevs et al. 2008).

According to modern phyto-geographic zonation the territory of the study area belongs to the southern district of the Turan province. Its flora comprises 450 species of higher plants of which 203 were first described as occurring in this region by the researchers of the nature reserve in 1983-1985 (Rustamov and Rustamov 2007). The flora of the river middle course comprises 96 plant species related to 67 genus and 37 families (Kerbabayev 1954). The flora of Amu Darya river valley from Termez up to the river delta encompasses 576 plant species (Ashirova 1971).

Certain species are fairly well adapted to survive under conditions of a highly dynamic river flow responsible for frequent floods and silting. These include in particular the dominant species of floodplain communities (Gladyshev 1992). The vegetation of the Amu Darya valley is represented by tree-shrub (tugai) and herbaceous (dzhangili) associations. Tugai forests are formed by two species of Poplar tree (Turanga): *Populus euphratica* and *P.pruinosa.* Turkmen oleaster (*Eleagnus orientalis)* and willow (*Salix songarica*) either occur in Poplar stands or make up small groves. Brushwoods are mainly composed of tamarisks (*Tamarix spp.*). *Halimoden-dron,* a torny shrub of the family *Fabaceae*, gives rise to dense thickets on saline soils. *Halostachys caspica* thrives on strongly salted soils. Trees and shrubs in tugai forests are entwined with lianas, such as *Cynanchum acutum, Clematis orientalis*, and *Asparagus* sp. On the whole, 25 different plant associations are distinguished in the tugai vegetation of the Amu Darya nature reserve (Rustamov and Rustamov 2007).

The Tugai vegetation can widely be distributed in the other habitants, while some species grow exclusively in valley conditions. For instance, *Saccharum spontaneum, Marsilea aegyptica Willd., Ophioglossum bucharicum O. et Fedtsch., Typha minima, T. elephantina, Dichostylis hamulosa (Bieb.) Nees, Bergia koghanii V.V.Nikit., Eulophia turkestanica (Litv.) Schlechter, Oxytropis riparia Litv.* The Tugai vegetation of Amu Darya valley is distinguished by the presence of some specific families, genus and species which are typical for moist tropical areas, for example: *Marsiliaceae Mirb., Ophioglossaceae*

(R.Br.) Agardh, Hydrocharitaceae Juss., Orchidaceae Juss., Malvaceae Juss., Elatinaceae Dumort. The sight of tropic flora elements can be explained by genesis of vegetation cover which began in Tertiary period. Most distributed plants in the Amu Darya valley and floodplain from family *Poaceae Barnhart* are giant cereals *Erianthus ravennae, Saccharum spontaneum and Phragmites australis (Cav.) Trin. ex Steud.* According to value in herbaceous structure and species amount the second place takes Fabaceae family. Its typical species is *Glycyrrhiza glabra L.*, then family *Tyhpaceae Juss., Tamaricaceae Link., Salicaceae Mirb*. and *Elaeagnaceae Juss*. (Gladyshev 1992).

The perennial herbaceous typically is more dominant in tugai vegetation - around 60 % from total amount of species. Annual herbaceous comprises 18.7 %, trees – 8.3%, shrubs – 13.5% (Gladyshev 1992). Desert areas adjoining the river valley give a home to 123 plants species including 83 psammophytes. Tugai vegetation comprises 43 species and that of meadow-boggy solonchaks 13 species. There are 23 species of weeds (Rustamov and Rustamov 2007).

Within the protected area, the dominant species belong to the five families most characteristic for desert areas of Central Asia, such as *Chenopodiaceae, Brassicaceae, Fabaceae, Asteraceae and Graminaceae*. They include many endemics. *Eulophia turkestana* listed in the Red Data book of Turkmenistan (Ministry of Nature Protection 1999) has been found at the site lying close to the nature reserve.

2.6.2. Fauna

During the last decades, the anthropogenic factors influenced the biodiversity in the whole region of Amu Darya River. Some species could survive because of the established protected areas. Therefore, talking about biodiversity of the whole study area we should take into account that it includes some part of protected areas where some species of flora and fauna were protected.

Nowadays, tugai forests serve as important habitats for many animals. Unfortunately very dense tugai forests mostly remained only in Amu Darya Nature Reserve which has a unique fauna. Suffice it to mention that extremely rare endemic fish species, Big Amu Darya shovelnose and Small Amu Darya shovelnose (*Pseudoscaphirhynchus kaufmanni, P. hermanni*), still live in the Amu Darya River while tugai woodlands provide home to the endemic Bukhar deer (*Cervus elaphus* Linnaeus). All three species are listed in the IUCN Red Data Book.

In 1978-1980 within the nature reserve 446 insect species including *Cicadidae* – 67, *Noctuidae* – 76, *Pyralididae* – 56, *Encyrtydae* – 86, and *Sarcophagidae* – 44 were identified and described. Gastropod molluscs and chironomid midges are the most abundant aquatic invertebrates represented by 12 and 35 species respectively (Rajapov et al. 2002).

High moisture of tugai forests makes them a favourable habitat for many dipterans. The abundance of mosquitoes, horse-flies, as well as phytophagous insects (bugs, acridids, beetles, and butterflies) is really astonishing. Desert occupying relatively large areas in the nature reserve are inhabited by wood-lice, solifugae, scorpions, spiders and a variety of insects including coleopterants, orthopterans, hymenopterants, etc. Rare insects, such as *Anormogomphus kirischenkoi, Hierodila tenuidentata, Leptothorax melleus, Amorpha philerema, Catocala optima, Glaucopsyche charybdis and Taragama faina* are listed in the Red Data Book of Turkmenistan (Ministry of Nature Protection 1999) .

Amphibians are represented by two species that occur at suitable sites along river banks and can be found outside of protected areas as well. The reptilian fauna comprises almost 40 species of which 26 species have been recorded in the nature reserve. In the Amu Darya valley, the Asian snake-eyed skink even more frequently occurs in oases where it occupies waste grounds, orchards, vineyards and edges of aryks. The

Red Data Book of Turkmenistan (RDBT) lists several reptile species known to occur in Amu Darya Nature Reserve and the neighboring territories viz. Khentau toad agama, Strauch's even-fingered gecko (*Alsophylax loricatus*), Desert monitor (*Varanus griseus*), Central Asian cobra (*Naja oxiana*) and Blunt-nosed viper (*Macrovipera lebetina*) (Marochkina 2006).

A total of 247 bird species and subspecies have been recorded in the Amu Darya valley of which 105 are local breeders (Marochkina 2006). Birds eat huge amount if eggs, larvae, caterpillars, and pupae of the pest insects and thus promote normal functioning of tugai ecosystems. Rare birds inhabiting the Amu Darya Nature Reserve and listed in the RDBT includes White and Dalmatian pelicans (*Pelecanus onocrotalus, P. crispus*), Spoonbill, Lesser white-fronted goose (*Aythya nyroca*), Marbled teal (*Anas angustirostris*), White-headed duck, Osprey (*Pandion haliaetus*), White-tailed eagle (*Haliaeetus albicilla*), Lesser kestrel (*Falco naumanni*), Owl eagle (*Bubo bubo*), etc. (Rustamov and Rustamov 2007).

Among some mammal species, the Bukhar deer deserves the special attention. Its numbers rapidly declined during the last decades. Only 10 Deer remained in 1960 and 15-20 Deer were preserved by the beginning of the 1980s due to the establishment of Amu Darya Nature Reserve. The mammalian fauna of the reserve nowadays comprises almost 40 species and is dominated by rodents and carnivores (14 and 13 species respectively). Other mammals of the reserve listed in the RDBT, besides Bukhar deer, includes Honey badger, Centralasian otter (*Litra litra Linnaeus*), Porcupine (*Hystrix indica*), Bobrinski's jerboa (*Allactodipus bobrinskii*) and Gazelle (*Gazella subgutturosa*) (Rustamov and Rustamov 2007).

2.7. Industry

The Lebap Velayat with an area of 93,800 square km is very rich with natural resources such as native sulphur (Gaurdak), natural gas (Gaz-Achak, Naip, Samandepe, Bagja, Gurtli, Sakar, Farab), potassium and cooking salts (Karluk), minerals, construction materials and small stocks of coal. Light industry is represented by cotton-cleaning (ginning), Karakul (lamb wool) preprocessing, wool-spinning, silk-weaving, sewing, shoe, knitted, carpet; flavoring (including butter-making), chemical (superphosphate, potash fertilizers and another), oil refining industries, metal working (including ship repair).The main industry enterprises are located in Turkmenabad (Chardzhou), Gaurdak and Kerki cities. Agriculture is maintained by an irrigation system (Encyclopedia of TSSR 1984). Over 2/3 areas are under cotton fields (National Institute of State Statistics 2005). Local people also sow lucerne, grain (corn, white dura, barley and others), melon plants (melons, water-melons), fruits and wine. Among others there are licorice preparation and processing and Karakul sheep breeding etc. In the past the Amu-Darya River played an important role in maintaining fish stocks of the Aral Sea. Its floodplains and delta with its lakes have created favourable conditions for natural reproduction of the major economic fish such as bream, carp and roach. But due to the lack of sufficient water resources the fishery is almost lost (Schluter et al. 2005).

2.8. Social aspects

The population of the Lebap Velayat is 1371,1 thousand people (2007) and its density is 12.5 person per square kilometer. The population is represented basically by villagers. On national structure Turkmen nationality prevails; other nationalities (Uzbeks, Kazakhs, Russian and others) occupy a small share. Average life expectancy of the population is 70 years, including women – 71.8, men – 69.9 years. About 43 % of the population is children, whereas elderly only comprise 4 % (Rajapov et al. 2002).

In 1992, "Ten Years of Prosperity," a government program was announced that provides virtually free natural gas, electricity, and drinking water to all households in the republic; increases minimum wages and other social payments, confirms food subsidies and price liberalizations, and aims at giving families their own house, car, and telephone. In 1993 two-thirds of the state budgetary expenditures went toward such social programs, and half of that amount for the subsidization of food prices.

One of the main indicators of a life standard is the monthly average salary. The monthly average salaries in the public sector in 2003 are presented in Table 3. The greatest salary is noted in geological prospecting and hydro meteorological service, science and transport.

Table 3. Average monthly wage in Turkmenistan (Marochkina 2005)

Sector	Turkmen manat ™	US dollars
Average wage	1 750 000	122.80
Geological prospecting and hydro meteorological service	2 514 200	176.44
Science	2 094 700	147.00
Transport	2 031 600	142.57
Agriculture (average in the country)	920 100	64.56
Agriculture (average in Lebap Velayat)	1 176 000	82.52

The monthly wage in agriculture sector for the whole country has the lowest level that is below average by 47 %. In Lebap province the monthly average wage in agriculture sector is below average by 28 %.

3. Methods

Different methods were applied to achieve the goals of the given Master thesis. The first method is the Literature review used to collect information for the chapters 'Study area', 'History of land use' and 'Environmental situation'. Data found through the literature review were analyzed by the Pressure-State-Response Model to gain insight into the environmental situation of the study area. The second method called Active interview was applied to collect initial data about the study area such as current information on land use practice, environmental situation, nature protection etc. The interview data were evaluated through the Hermeneutic Method, i.e. by interpretation which enables the reader to understand the main message of the respondents.

3.1. Literature Review

Literature from various sources was reviewed to collect information about the Amu Darya region, i.e. general issues, social-economic aspects, land use practice, ecological problems etc. to describe the study area, its land use history and environmental circumstances. The emphasis was on the Amu Darya middle reach which flows through Lebap province in Turkmenistan. Data sources were books, journals, websites and databases dealing with Amu Darya River and water consumption, agriculture, environment and Tugai vegetation. In order to find relevant literature the following four search strategies were used:

a.) Government official documents – database of the Ministry of Nature Protection, National Institutions, statistical data etc.
b.) Library resources
c.) Database search using Web of Science *(via Greifswald Library)*
d.) General internet search using *Google* and *Google Scholar*

Government official documents

The main agency dealing with ecological issues in Turkmenistan is the Ministry of Nature Protection which published many books related to different aspects of the environment. For the given thesis, the National Environmental Action Plan (2002), the Red Data Book, the national reports “State of Biological Diversity of Turkmenistan (2002), “Biodiversity Strategy and Action Plan for Turkmenistan (2002), the report “Turkmenistan: Initial National Communication of UNFCCC (1999) and “National Program to Combat Desertification in Turkmenistan”(2000) for the appropriate UN Convention were used. Also, well-known International Scientific journals such as “Problem of Desert Development” of the National Institute of Desert, Flora and Fauna and the Scientific-theoretical journal “Science and Technique” of the Supreme Council on science and technology under the President of Turkmenistan were reviewed. Statistical handbooks were available only by the World Bank (1992 -1996).

Library resources

Since all information related to Tugai vegetation along the Amu Darya River was collected 15 years ago I browsed in old books that were not available online. For this purpose, I investigated relevant literature in databases of the Science Academy Library of Turkmenistan. In the library, the desired information was limited in edition (Ashirova 1971; Gladyshev 1992).

In addition, I found some useful literature in my own home and office library, such as the Encyclopedia of TSSR (Encyclopedia of TSSR 1984) and climate data (Orlovsky and Volosyuk 1974) and reports of

the UNEP project on Second National Communication on UNFCCC (Allaberdiyev 2006). Attempts to find relevant information about my study area in the library of Greifswald University was unsuccessful.

Database search using Web of Science (via Greifswald Library)

Web of Science was recommended for a broad search of scientific articles since its databases cover almost 10,000 leading journals of different subjects and over 100,000 book-based and journal conference proceedings. I began my search using a combination of key words such as *Amu Darya* and *environment*. As the search yielded surprisingly few results, I progressively broadened the scope of my search using various combinations of key words such as *agriculture in Turkmenistan*, *Lebap*, *Amu Darya water consumption*, and *Tugai forests*, including the use of wildcard characters to allow for variations of these terms. The search results had wide variety but not all of these papers were accessible.

General internet search

In order to get a broader overview of articles related to the Amu Darya region and its environmental condition I searched for the same key words as mentioned above using *Google* and *Google Scholar*. Additionally, I performed a brief search for the equivalent Russian terms, e.g. *регион Амударьи* (Amu Darya region), *окружающая среда* (*environment*), *сельское хозяйство* (*agriculture*) and *тугайные леса* (*Tugai forests*). This search enabled to browse the Portal of Knowledge for Water and Environmental Issues in Central Asia (www.cawater-info.net). This portal holds a huge base of information, knowledge, and data related to water in Central Asia including Turkmenistan. Despite its informative capacity this portal like many others has several disadvantages such as absence of authors' names and references, and date of last modifications.

In addition to the abovementioned search strategies already employed I investigated relevant literature in library databases as well as in the reference lists of articles that I found so far. The overall result of my recent literature search was rather unexpected. The official Government books contain data on the entire country, but not specifically on the study area. Gaining national statistical data is very difficult and they are not available online at all.

As for the online search, there seem to be only a small number of general articles focusing on Amu Darya river issues mostly water resource deficiency and water distribution problems. However, some interesting books and articles were not accessible online free of charge.

3.2. Pressure-State-Response Model

The Pressure-State-Response (PSR) framework has been applied in order to analyze the interactions between environmental pressures, the state of the environment and environmental responses.

The PSR framework was initially proposed by Tony Friend and David Rapport. PSR model is based on the concept of causality: human activities exert pressures on the environment and change its quality and quantity of natural resources ("state"). Society responds to these changes through environmental, general economic and sectoral responses ("societal responses") (OECD 2009).

The environmental pressures relate to pressures from human activities exerted on the environment, including natural resources. 'Pressures' cover underlying or indirect pressures, which act as driving forces for environmental issues (i.e. the activity itself and trends of environmental significance), as well as proximate or direct pressures (i.e. the use of resources and the discharge of pollutants and waste materials). Indicators of environmental pressures are closely related to production and consumption patterns; they often reflect emission or resource use intensities, along with related trends and changes

over a given period. They can be used to show progress in decoupling economic activities from related environmental pressures. They can also be used to show progress in meeting national objectives and international commitments (e.g. emission reduction targets).

The environmental pressures in our study area include human activities and natural causes. The main human activities are steady growth of the agriculture, industry, oil-gas, energy, transport sectors. These driving forces are more aggravated by the population, economic growth, changes in lifestyle. However, some natural causes are also considered as environmental pressures such as climate change, fires and geographical features.

'State' means environmental conditions related to the quality of the environment and the related effects or impacts, and the quality and quantity of natural resources. They cover ecosystems and natural environmental conditions as well as quality of life and human health aspects. As such, they reflect the ultimate objective of environmental policies. Indicators of environmental conditions are designed to give an overview of the situation (the state) concerning the environment and its development over time.

In the study area, stated environmental pressures have led to depletion of the natural resources e.g. water shortage, different type of soil degradation, air, soil and water pollution, Aral desiccation and low quality of human health.

'Response' implies society responses to environmental concerns through environmental, general economic and sectoral policies and through changes in awareness and behaviour. They refer to individual and collective actions and reactions that are intended to mitigate, adapt to or prevent human-induced negative effects on the environment; halt or reverse environmental damage already inflicted; preserve and conserve nature and natural resources (OECD 2009).

In the given area, water resources have been considered as priority environmental issue since they are under extreme pressure. Therefore, suggested measures related to sustainable water management.

3.3. Interview

The interview data conducted in the study area are important because they allow us to assess expert and local peoples' perspectives and how they think about management system in the given region. Moreover, if we want to find sustainable solutions we need to have the acceptance of the local people.

Two rounds of interviews were conducted for experts and local people in the study area – Lebap Velayat and in Ashgabat city from March to April 2009. In the study area the interview was conducted in the nearest settlement to the Amu Darya Nature Reserve in the Kabakly village and a village close to Turkmenabad (administrative center of the Lebap Velayat).

The key element of the interview was the questionnaire. When developing the questionnaire local circumstances and cultural features were taken into account. The final version of the questionnaire was discussed with and approved by the Ministry of Nature Protection of Turkmenistan. For national experts the questionnaire was not changed while for local farmers on recommendation of the Ministry it was simplified and translated into the local language.

The interview questions can be divided into four categories. The first category encompassed questions related to the environment of the study area, the second focused on land use practice in the study area, the third and fourth categories on nature conservation issues and related problems.

A total of 24 people of different age and sex were interviewed. 14 people represent the expert level while 10 people represent the local level. The expert interviews were conducted in the Ministry of Agriculture,

the Ministry of Nature Protection and its different branches dealing with environment issues. The structure of the interviewees was as follows:

- 1 person from the Ministry for Agriculture – Head of Protection and Rational Utilization of Land Resources Service;
- 2 people from the Ministry of Nature Protection - one Head of Flora and Fauna protection department and one Deputy Head of the same department;
- 1 person from the National Institute of Desert, Flora and Fauna - Climate Change Specialist, simultaneously the National Focal Point on IPCC;
- 6 people from the Nature Protection Department of Lebap province – one Department Chief, one Head of control-inspection and ecologic expertise division and two Senior Specialists from the same division, two Specialists dealing with land use and agriculture issues;
- 4 people from the Amu Darya Nature Reserve – Director of the reserve, Head of Scientific Department, State Inspector and one Junior Researcher.

In the Kabakly village, 4 local people were interviewed – one from the local authority (*Archin orunbasary* - deputy of the village head), one aksakal (village elder), one imam and one local farmer. In Turkmenabad village, 6 farmers were interviewed. All of them leased a plot of land from a peasant association where they grew different crops such as cotton, wheat, rise, sugar beet etc. One respondent among the local farmers was a woman who helped her father in the household plot.

Among all respondents only 3 were women. The age of all respondents was within the range of 25-50. The selection of participants was small, but it enabled for estimations of the given region as a whole, the current land use system, nature protection activities and others. The interview for experts was conducted upon the official permission of the Ministry of Nature Protection which is the main organization dealing with ecological problems in the country while the interviews with local farmers were conducted spontaneously, with a random choice of the respondents.

Prior to the interview, the purposes of the survey were shortly introduced and confidentiality of answers assured. All respondents agreed to participate in the interview. Russian and Turkmen languages were used for the interview. Questions were asked, clarified when needed and answers were written down while respondents replied. The process of the interview lasted no longer than 15 min. All answers were translated into English and typed in both Russian and English languages.

For better understanding the respondents' opinions we categorized them into two groups - experts (14 people) and local people (10 persons) - according to their origin, background and knowledge. Furthermore expert group was divided into two subgroups – urban experts and local experts. The reason of this division was that the urban expert subgroup includes 4 specialists (17%) from the capital of the country i.e. outside of the study area and represents decision making level. The local expert subgroup consists of 10 specialists (42 %) and represents local expert level. The experts of this subgroup are employees of Amu Darya Nature Reserve and Nature Protection Department which located within the study area.

Categorizing of interviewees enabled to clarify some results of interview evaluation. Since opinions of the groups were different I retrieved similar answers and held them separately. Categorized answers were illustrated in charts after certain interpretation of interview data. It should be remarked that all charts show only the tendency of opinions or situations given by respondents and thus these data are not representative information.

4. Results

This chapter consists of the three main parts. The first part reveals the information about land use history of the country; the second part presents the interview data of the experts and local people; and the last part describes the current environmental situation, determines priority ecological problems of the study area and proposes some theoretical solutions on water related issues. Information and data for the first and last parts of this chapter were obtained through the literature review while the interview data were gathered this year during the interview.

4.1. History of Land Use Systems in Turkmenistan

The current situation in the Turkmenistan must be understood in the first instance from a more historical perspective – it is the history of the country. If one makes suggestions for the future of a country it is important to have sufficient knowledge about the past of this country and to understand why things have changed.

While talking about the land use practices of Turkmenistan we should take into account the historical events which had considerable influence on the agriculture as whole. We have divided the history of land use into three stages according to different land and water use practices of the country. The water and land use practices in Turkmenistan were described in detail by R.Lewis (1966) in 'Early Irrigation in West Turkestan' and S.O'Hara (1999) in 'Irrigation and water management in Turkmenistan: Past systems, present problems and future scenarios. Therefore, I mostly refer to their data.

4.1.1. Prior to Soviet Union Period

Despite its aridity Turkmenistan has a long history of agriculture and settlement, boasting some of the oldest known irrigation sites in the world. Once established some 7000-8000 years ago, irrigation spread gradually across the region with the development of a series of extensive oases and by c. 2000 years ago large tracts of land were irrigated in the region's better watered locales (Lewis 1966).

As irrigation networks expanded, methods to control and manage them developed and it is likely that sophisticated organizational structures were in place at an early stage, although relatively little is known of them. During the period when Turkmenistan came under Persian rule, in the first century BC, the area of land irrigated grew significantly (Lewis 1966). It was reached by using the underground irrigation system locally called 'kyariz'. Kyarizs were the traditional hydro constructions created for carrying the ground waters out on the earth surface. They were used by people for a long time. According to historical data, in territory of Turkmenistan Kyarizs were constructed in 5^{th}-2^{nd} centuries BC nearby to Parfiya and Anew sites (Encyclopedia of TSSR 1984; Ovezmuradov 2008).

Starting in the 5^{th} century, AD periodic invasions by nomadic groups, such as the Huns, brought instability to the region with the widespread destruction of settlements in the main irrigation zones. Once abandoned, these lands rapidly reverted to desert. Stability returned in the latter part of the 7^{th} century when the region came under Arab control and the early Islamic period saw renewed prosperity with irrigated agriculture flourishing. Major engineering works were undertaken with the development of extensive and sophisticated irrigation networks and water was often taken many miles from its source to allow new lands to be cultivated.

It was during this time that Merv, located in the delta region of the Murgap river, emerged as one of the major cities and cultural centres of its time which, in the 11th-12th centuries, had an estimated population of over one million people who cultivated an area of 700 km^2. Merv had access to only one source of water, the Murgap, which rises in the Afghan mountains and drains northwards into the Karakum desert. The river' s mean annual discharge is approximately 1.3 km^3, about 5% of Turkmenistan' s total water budget today (Orlovsky and Orlovsky 2005). Despite having access to only a relatively small amount of water, the oasis not only produced enough food to feed its large population but also to export to adjacent areas. The region' s agricultural success was due in part to the land and water management strategies of the time. Land was divided into small plots that were intensively cultivated and watered on a regular basis. Decisions on the amount of land to be sown were based on spring flow and in years of low discharge only essential lands were cultivated (O'Hara and Hannan 1999). Water gauges were also installed on every canal in the city and the distribution of water was carried out with great care. In charge of the system was the Mirab (from the Arabic *mir* - master and *ab* - water) whose post was one of the highest in the state. Hourly reports on the level of water in the main canal were passed to his office and, based on this information instructions for following activities were circulated by messenger to the officials in charge of every off-take. A huge number of people were employed in managing and maintaining the system, reaching 12 000 by the 12th century, the cost being met by taxes levied on water users. In addition to water payments, individual water users were also obliged to take part in annual maintenance works which involved the cleaning of irrigation and drainage canals as well as the construction of new structures.

In the first quarter of 13th century, the Mongol invasion was to spell the end for Merv and indeed other major Central Asian cities of the early Islamic period (Encyclopedia of TSSR 1984). The speed of their conquest was due in part to the fact that large populations had become reliant on a single source of water. At Merv for example, they only needed to destroy the main control dam to bring about its fall (O'Hara and Hannan 1999) a tactic they employed across the region. Although many settlements re-emerged, few were to regain their former glory and it was to be many centuries before the region' s irrigation network was again to reach the size it had been prior to the arrival of the Mongols.

In the early 18th century, Central Asia became the focus of Russian expansionist plans when the Tsar, Peter the Great, began a series of campaigns that over the next 165 years was to result in Central Asia being annexed. The last area to come under its control was Turkmenistan. At that time local people implemented an irrigated agriculture in a combination with nomadic cattle breeding. Turkmens lead a semi nomadic life style and some inhabitants of one village were cattlemen and the others were sedentary farmers. The western Turkmens basically were cattlemen-nomads (sheep, camels, horses), while Turkmen living in oases, focused on agriculture (wheat, white durra, melon, cotton) and cattle breeding. Almost till 80th years of XIX century there was a patriarchal slavery; archaic division into «thoroughbred", "slaves" and descendants from mixed marriages with slaves remained. Main agricultural fields and pastures were owned by Bai (rich landowner in Central Asia): about 40% of crops and 60% of livestock belonged to them. The class differentiation of land ownership strengthened. The water and land property right had only the numerous rich clans and tribes (Encyclopedia of TSSR, 1984).

Once subsumed into the Russian Empire, teams of agricultural and engineering experts were sent to the region to assess its agricultural potential, particularly for large-scale cotton cultivation. The wide-spread remains of ancient irrigation systems made it clear to the Russians that there could be a substantial increase in the amount of land cultivated and plans for various large-scale irrigation schemes were drawn up.

Although there was a considerable increase in the amount of land irrigated during the Tsarist period it generally involved the expansion of existing irrigation systems with little development of wholly new

lands. People began to grow up more productive sorts of the cotton. The Turkestan republic harvested 2,88 tons of cotton in 1893 and 37,78 tons in 1910. Areas under the cotton, wheat and barley in 1890 comprised 47,96 thousand ha, including 4.3% land under the cotton from total area and in 1914 the irrigated area accounted 154,04 thousand ha and 34% respectively. Crop yields were still relatively low (Encyclopedia of TSSR 1984). Thus irrigation schemes still remained relatively small and continued to be associated with a single water source with little change in the way water was managed.

4.1.2. Soviet Union Period

The Bolshevik revolution in 1917 and subsequent emergence of the Soviet Union was to herald a period of radical change in the way in which Central Asian water and land were managed and had profound implications for Turkmenistan. Water and land were no longer owned by individuals but were common resources to be developed for the benefit of all. The Central Asian Republics, particularly Uzbekistan and Turkmenistan, were designated as cotton-growing regions and in November 1920 Lenin issued an edict that the cotton industry in Central Asia was to be reconstructed (O'Hara and Hannan 1999; Obertreis 2008).

In order to meet production targets irrigation had to be expanded and from the start the Soviet administration invested considerable sums of money in developing irrigation infrastructure. Over the next 70 years more and more land was sown to cotton (Table 4) and the entire agricultural and industrial base of the republic was geared towards its production.

The limited amount of water available, however, placed a major constraint on agricultural development and so, drawing on plans first outlined by Tsarist engineers, the Soviet authorities began construction of a series of canals which diverted water from the Amu Darya across the Karakum desert. The first major project was the Bassagi-Kerki Main Canal, close to the Amu Darya River, which was the forerunner for the Karakum Canal. Construction of the canal proper began in 1954 and was completed in 1988, involving the transfer of water to the southwestern part of the republic (Fig. 1). Today the Karakum Canal diverts 12.9 km^3 of Amu Darya River water along its length, irrigating approximately 1 million hectares of land, and has turned southern Turkmenistan into a major agricultural zone. The use of agricultural machinery also became important and by the 1980s Turkmenistan had one of the most mechanised agricultural sectors in the Former Soviet Unions.

Agrarian reforms over the period of 1918-1924 created conditions for implementation of Land-Water Reform (1925-1927). This reform has adjusted land use between 6128 peasant units from which 1038 associations received the land and water at the first time. Reform eliminated 2298 rich landowner's household and withdrew 19,8 thousand ha of land from 15,6 thousand households (husbandry). As a result of reform of 10,4 thousand landless peasant obtained the land and 23,2 thousand small households increased their plots. The Reform initiated a socialist transformation of agriculture and became as component of Lenin's socialism construction plan. In 1926 the first 8 collective farms were established in Turkmenistan. As a result of mass collectivization by the end 1932 there were 1308 collective farms in republic united 75 % of peasant households (Encyclopedia of TSSR, 1984).

With an establishment of a collective-state-farm system the agriculture of the republic sharply developed. By year of 1940 the sown areas were enlarged to 360 thousand ha, including area under cotton to 150 thousand ha (Table 4). The national gross production for agriculture in comparison with 1913 increased in 1928 in 1.2 and in 1940 – in 1.5 folds.

Table 4. Variations in the area of land irrigated, and sown to cotton and wheat 1884-2005 (Ohara 1997; O'Hara and Hannan 1999; Stanchin and Lerman 2005)

Year	Area irrigated (th. ha)	Area sown to cotton (th. ha)	Area sown to grain (th. ha)
1884	63.5	1.0	-
1914	168.0	62.0	-
1917	104.9	1.5	77.6
1924	242.0	40.0	121.0
1940	360.0	150.0	183.0
1950	348.8	153.0	128.0
1958	393.6	222.0	71.0
1965	521.4	257.0	133.0
1970	668.1	397.0	84.0
1980	964.0	508.0	132.0
1990	1231.0	623.0	184.0
1995	1494.0	563.0	657.0
2000	1484.0	619.0	760.0

Despite such changes in field size, traditional surface irrigation, whereby water is applied to the crop at surface levels, usually along furrows that traverse the field, continued to predominate. As a result it took days rather than a few hours to water individual plots and the tradition of nigh time irrigation gave way to day and often 24-hour continuous irrigation. This was to increase water use significantly.

The situation was exacerbated by the fact that the Karakum Canal provided a plentiful, and what appeared to many, infinite supply of water which was essentially free of charge. Together with the lack of monitoring equipment, particularly at the on-farm level, this meant that determining the amount of water being applied to a field was virtually impossible and as a result over-watering was and still is endemic. Over-watering coupled with inadequate drainage meant that new irrigation systems were plagued with problems of waterlogging and secondary salinisation. Thus, unlike traditional systems which were sustained for hundreds and even thousands of years with little evidence of degradation, Soviet-built irrigation schemes brought about widespread and rapid land degradation which by the 1970s was to result in land in Turkmenistan being abandoned at a rate of over 46 000 ha per annum (O'Hara and Hannan 1999). Thus, the Soviet Union style of agriculture was not well adapted to condition of Turkmenistan.

Obligatory communal maintenance that had been central to traditional irrigation systems also declined during the Soviet period, particularly as greater use of machinery was made. There emerged in its place a number of government bodies which were responsible for maintaining the irrigation infrastructure. Only that part of the system incorporating the garden plots was the responsibility of individual water users and as such the number of people involved in maintaining the system was substantially reduced. It was not only the size of the system that changed during the Soviet period, but the entire way in which water was managed. Individual irrigation zones were no longer linked to a local source and water was often transferred considerable distances.

Cotton accounted for more than 50% of the sown area all through the 1980s (Table 4). Unlike the former time farmers planted only high-quality sorted species which were produced by research institutes. The raw cotton was transported to the new enterprises constructed since the first years of Soviet Union period. Most part of cotton production were delivered to the “brother countries” with other production as sulphur, oil, natural gas, iodine, sulfate sodium etc. Another 30% was under feed crops (mainly grasses), which played a very important role in crop rotation keeping the soil healthy for cotton. Grain (mainly wheat) was grown on a mere 15% of the cropped area. Therefore the bread staff was imported from other Soviet Unions. This cropping pattern remained largely static during the last centrally planned decade of the

1980s (Stanchin and Lerman 2005). Other branches of agriculture intensively developed as well. Apart of technical crops (cotton, sesame) were wine production, melon and gourd cultivation, subtropical culture (olive tree, granatum), feed corns (wheat, barley, oats, lucerne, maize, winter rye etc) and silk production were grown only in small area.

By the time the Soviet Union collapsed, over 1.3 million hectares of land in Turkmenistan were cultivated, with agriculture forming a vital component of the country' s economy and accounting for 40% of GDP. The expansion of the agricultural sector during the Soviet period was not without cost, however, and at independence Turkmenistan not only inherited established cropping patterns and associated river withdrawal limits, but a large amount of dilapidated and obsolete agricultural equipment, a highly inefficient irrigation system, as well as a vast area of land that had been degraded by decades of agricultural mismanagement.

Moreover, despite agriculture growth, the Soviet industrialization left a legacy of ecological devastation, monoculture development, and an obsolete, rapidly deteriorating infrastructure. Most industrial development in Turkmenistan under Soviet rule was oriented toward heavy industry, especially in chemicals and petrochemicals. The food production was practically undeveloped. Over 70% of the necessary finished products were imported to the country including the grain. The cotton monoculture became the reason of food dependence of Turkmenistan and has generated a raw orientation in development of all agricultural sectors.

4.1.3. Independent Turkmenistan (Past Soviet Union Period)

The country has continued to employ the Soviet system of water management, although with the loss of central planning and funding, decisions are now made by the Turkmen Cabinet of Ministers, who also set spending limits. However, changes in social, economic and political conditions within the republic, the Central Asian region and the Former Soviet Union as a whole are having a considerable impact on irrigation and water management in Turkmenistan. Currently, 90 to 95 percent of water in the country is used for irrigation; the remainder is used for industrial and municipal consumption. Government has allocated land and water resources for free of charge and has incurred expenses on irrigation- ameliorative and water supply activities (Stanchin and Lerman 2003).

The main change in agrarian reforms can be characterized as a shift from collective farming to a more individualized agriculture. The first step (1990-92) involved distribution of irrigated land to rural families, which more than doubled the total size of the household-plot sector to 133,000 hectares. The second step (1993-96) involved a national program for allocation of land to independent private farmers who were allowed to engage in commercial agriculture outside collectivist frameworks. Today there are more than 5,000 such private farms in Turkmenistan operating on 81,000 hectares (Lerman and Stanchin 2003). The third, and perhaps the most radical step (1996-97) involved the transformation of former collective and state farms into associations of leaseholders. So-called "peasant associations" (daikhan berleshik) replaced the traditional collective and state farms, and each association was instructed to parcel out its large fields to individual leaseholders. The peasant associations administrate state-owned agricultural land and transmit state orders to the leaseholders. In order to lease a land farmer have to conclude land-lease contract with the association. Additionally, associations are the municipal authority responsible for maintaining rural infrastructure in the villages – and they receive a certain payment from the leaseholders for these services.

The main goals of the Turkmenistan agrarian reforms are to increase the role of the private sector and to raise water use efficiency and land productivity. In 1996, the President of Turkmenistan announced his

intention to accelerate land reforms and announced that the lands of the peasant associations would be transferred to the private sector. In the first instance, farmers will be allowed to lease land free of charge but will be required to grow and attain target yields in selected crops, mainly cotton and wheat. After two years, if output performance is considered satisfactory, the leased land will become the farmers’ property. Once they are given land ownership the farmers will be free to grow what they wish.

The reforms aimed at household plots and private farms, however important, were marginal by the amount of land that they encompassed. The transition to leasehold contracts, on the other hand, involved more than 350,000 rural family units and 1.5 million hectares of arable land, i.e., practically the entire rural population and 90% of arable land in Turkmenistan (Lerman and Stanchin 2003).

At independence Turkmenistan produced less than 30% of all its basic food and consumer goods (Muller 1994). Therefore, one of the first initiatives of the new government was the `Grain Program’, which aimed to make the republic self-sufficient in grain by 1996. It forms part of a wider plan, adopted in 1994, known as `Ten Years of Prosperity’, which calls for a substantial increase in agricultural output, not only for basic food stuffs but also cotton and other industrial crops. Increased output was achieved by expanding irrigation and improving crop yields (Fig. 7). The area under wheat was increased from 15% in 1990 to 50% in 1998 and the early 2000s. The increase in wheat areas came at the expense of some reduction in cotton cropping (which dropped from 50% in 1990 to 40% around 2000), but mainly due to a sharp contraction of areas cropped to grasses (which dropped dramatically from 27% in 1990 to a mere 3% around 2000). After 2002 national statistics register a sharp unexplained increase in areas under grasses and other feed crops, which this time came at the expense of cotton-cropped areas: grain areas remained unchanged at around 50% of sown land.

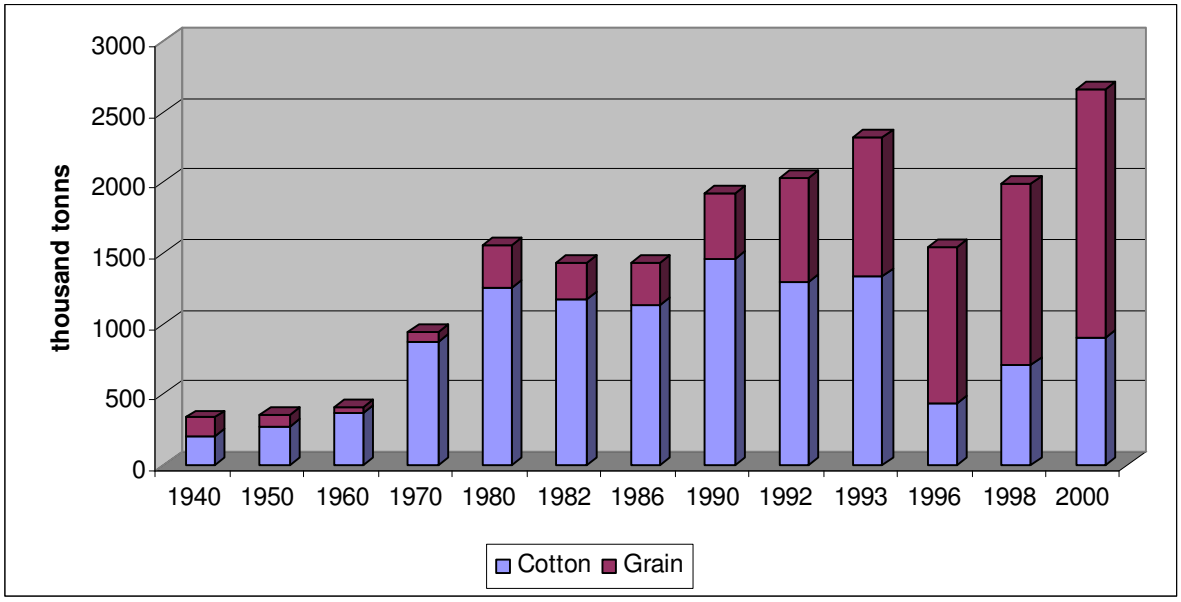


Figure 7. Dynamic of the main commodities of Turkmenistan for 1940-2000 (Encyclopedia of TSSR 1984; Baydildina et al. 2000; Lerman and Stanchin 2003).

As for other types of agricultural production, in 1998 milk production increased 62.5% over 1992 levels; meat production increased 23.7%; wool production, 14.6%, and grape production, 13.6%. Vegetables, melon crops, fruits, potatoes, eggs, and astrakhan wool production decreased during the period examined because of decreases in production by the state sector. Thus, due to the food self-sufficiency objective of the government, greater emphasis has been placed on grain production at the expense of high-value crops.

One of the features of Turkmenistan's agriculture is the introduction of privileges for agricultural commodity producers who perform the state deliveries of grain, cotton and a sugar beet. These privileges mean that the farmers (leaseholders) pay only 50% discount price for the main agricultural inputs (seeds, fertilizers, pesticides and the mechanized works). However, farmers then have to sell their produce to the state at fixed prices which are lower than market prices (Lerman and Stanchin 2003).

Today more than 40% of manpower is involved in the agricultural sector, and the sector's share represents as much as one-third of GDP (Baydildina et al. 2000). Agricultural outputs and raw materials are very important for the textile industry.

4.2. Interpretation of Interview Data

1. **How would you characterize the current state of environment situation along the Amu Darya in Lebap Velayat?**

Good situations: Eight local experts and one urban expert highlighted the two main components of the environment of this region – riparian forests (Tugai) and Amu Darya River. All these experts (64%) said that generally, the condition of the environment is good. Naturally, this region is represented by Tugai forests. Dominating species are turanga *(Populus spp.*) and Tamarisk *(Tamarix spp*), the licorice (*Glycyrrhiza spp*) and reed *(Phragmites*). Along with a protection function, the Tugai forests regulate river water and fix a soil. For economic targets on open sites, the mulberry is grown as a water regulating tree. The Head of Nature Department said that Tugai is considered valuable. It should simply be left alone and even after disasters should not be touched, and then it can well restore itself. Nearly all local people (80%) described the state of environment in positive ways admiring beautiful nature, forests and many animals along Amu Darya River. They emphasized the significant value of Amu Darya River and their heavy dependence on it.

Negative situation: However, some experts (36%) concluded that the condition of the environment was under strong human influence. Human activities such as cattle breeding, cultivation of various species especially cotton and wheat, and clear cutting had negative effect on the state of environment especially to the Tugai forests. The employees of the nature reserve concluded that only within the protected area the state of environment was good, while outside the situation was much worse. One local farmer also confirmed the fact that before this region was rich with forests but due to agriculture people cut them down in order to cultivate these lands and plant cotton. Other distinctive feature of Lebap Velayat is the Amu Darya River. All interviewed people emphasized the significant role of this river for their life, their economic activities and a life of animals and plants. One urban expert stressed the importance of water availability in the Amu Darya River. He explained that if there is less water in the river, empty patches occur on which nothing grows. In such conditions animals can not reach the water because the land is waterlogged and animals fall into it. One urban expert added that recently due to water scarcity the situation has become worse. One farmer also said that the river's water has become dirtier than before and less.

Figure 8. Interviewees' opinions regarding the environmental situation in the study area, people.

2. How would you characterize the environmental situation compared in the past to today?

Respondents were asked to compare the environmental situation today with those 20 years ago. Many experts declared that the pressure on the environment has increased. Actually, environmental conditions outside of the protected zone have worsened due to different causes, noted experts. After establishing Amu Darya Nature Reserve in 1982, the ecological situation much improved within the protected area because these territories are simply not accessible. The Head of Lebap Nature Protection department stated that today protected areas cover only 4% of the country, and to improve the ecological situation in some regions the territory of protected areas should be enlarged to 10%.

Situation better or no changes: Three local experts said during the interview that the ecological situation in the Amu Darya region was better than before. Some local farmers (40%) also stated that the environmental situation had improved and one said that nothing had changed for the last 20 years.

Tugai forests reduced: A great concern was also expressed by many experts (43%) about the state of Tugai forests which were tragically reduced. 36% of respondents admitted that the area of agricultural fields has increased and their condition has become worse as a result of using different agro chemicals. The director of the reserve said that in the past Tugai forests covered more than 30 thousand hectares but today only 6000 hectares are left within the protected area. They were cut to give space to agricultural fields. One urban expert who grew up there said that he occasionally visited his relatives and found that forests which once were very dense have simply disappeared because they have been almost cut down. Nothing remained from forests now, he said. One local farmer also said that many trees were cut down before but now people started to grow pines in order to improve environmental situation.

Climate change: Two urban and two local experts were concerned about weather which became hotter. Animals hardly tolerant such conditions, said one expert. Farmers (30%) also observed changing climate. Both experts and local people gave examples of events which happened last year. During that time, there were few rains and winter was extremely cold which affected nature and agriculture.

Less water resources: Two urban experts highlighted the increasing water scarcity which was observed during the last two decades and one of them gave the example of the Aral Sea disaster. This circumstance also was confirmed by one local farmer who stated that the amount of water in the river was decreasing.

Biodiversity reduced: During the specified period, many animals inhabiting these forests have become endangered. For instance, 405 deer (*Cervus elaphus bactrianus* Lydekker) inhabited the area, and now

only 120 remain said one inspector of the reserve. One local farmer noted other phenomena. The fish stock in the Amu Darya River declined, which was probably observed during the fishing process.

Only one farmer said that the situation has worsened but did not characterize to what extend and what exactly has changed so far.

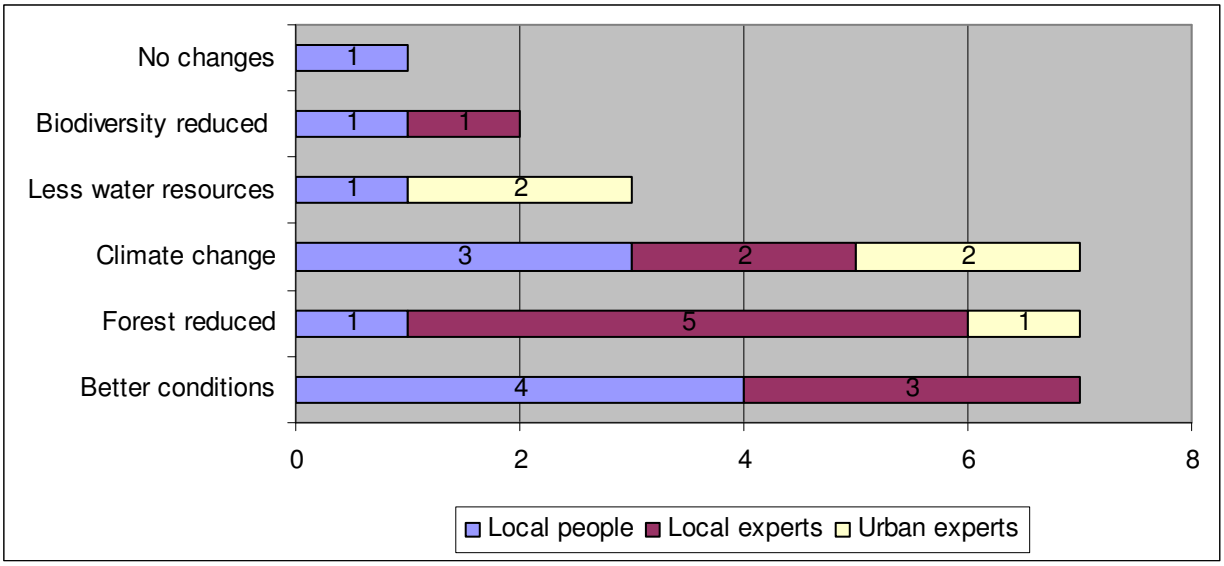


Figure 9. Interviewees' opinions regarding current environmental situation compared to past, people.

3. What environmental problems are the most important and what is source of these problems?

During the interview nearly all people listed many different problems which influence the environment of the study area. The most stated ecological problems were related to human activity and population growth.

Pollution: The source of water pollution comes from Uzbekistan (Karshinsky area) where return waters from agriculture fields with considerable amounts of salts and pesticides flow into the Amu Darya River, said experts. Additionally, usage of fertilizers in agriculture contaminated not only soil but also water. In the northern part of the country (Dashoguz region), the water actually becomes non-potable. Air pollution was another ecological problem in the study area stated by two experts and three local farmers. Certain numbers of enterprises release different emissions to atmosphere. For example, the in Turkmenabat city the Phosphoric factory contaminates the atmosphere and discharge polluted waters into the Amu Darya River.

Clear cutting and fires: Concerning the degradation of the Tugai forests, main threats were clear cutting and fires. The experts said that clear cutting was conducted mostly in order to open new farmlands. The main sown crops are cotton and wheat. Some experts agreed that cultivation was also necessary because population was growing and the demand on food and clothing increased simultaneously. They highlighted that however, nature preservation was very important to preserve natural resources. Fires happened mostly outside of the protected zone said one respondent and due to the high density of Tugai vegetation said another respondent. The reed and Tugai vegetation has specific roots which protect and fix soil. If there are fires then root systems decay and water washes away soil along the river.

Climate variation: Two experts and two local farmers stated climate change as the main environmental problem in the study area. Variation of climatic conditions had an impact on the environment and accelerated processes of water resource reduction, stated some of them.

Water problems: Two experts raised water scarcity problems. They said that the source of water scarcity was the increase of water intake by upstream countries – Afghanistan and Tajikistan. Each country uses river's water for various purposes. Consequently, there are reduced water resources in the middle and lower courses (Nukus area). Population numbers increase from year to year, therefore water demand grows and agricultural fields increase. Furthermore, both interviewees expressed concerns regarding the platinum for the hydroelectric power station which recently was being built in Tajikistan. There was an initial estimation that this huge construction would leave this region without water for 2 years. One local person also complained that farmers faced water shortage for irrigation. In additional to water problem, three local specialists mentioned the change of the Amu Darya river course which happened last year and in 1969. To prevent flooding, after which the river would change its course, people broke the river ice through explosion.

Others: Among other ecological problems were overgrazing (1 expert) and soil salinization (2 experts). Four out of ten local people living in Kabakly village said that there was no harm to the state of the environment.

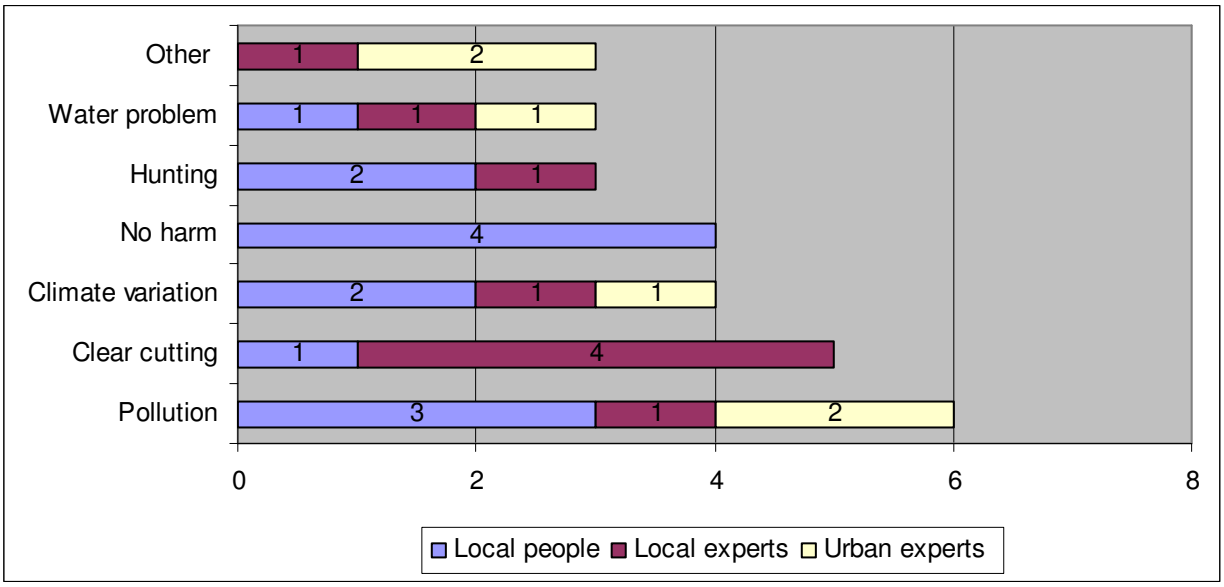


Figure 10. Interviewees' opinions regarding the environmental problems in the study area, people.

4. What problems would occur due to climate change?

It is well know that climate change is expected to negatively affect many arid regions in Asia. Against the background of climate change and shrinking river runoff, we raised the question whether the problems occurred due to climate change in this region. Curiously enough, all representatives of both groups declared that climate was changing and had negative effects on the state of environment. However, the climate change induced problems stated by both group were relatively different.

Nearly all experts (93%) stated that climate change would negatively influence the entire region and lead to many ecological problems, mainly water shortage and dryness. This problem in turn would threaten flora and fauna; days with drought would increase and in the end aggravate the ecological situation in the region. Only one respondent from the Ministry of Nature Protection said that he found it difficulty to reply.

It is important to notice that almost all local people agreed that climate change would negatively affect the people's welfare and health. They associated climate change with last year's frosts. The temperature in the winter of 2008 reached unprecedented values of minus 16 ^{0}C. Six out of ten local interviewees underlined

that these frosts did a great harm to their households – a lot of cattle died, the river and soil froze, vineyards were lost and cut down. Any sharp change in weather caused big loss to our fragile nature and our economy, said one local farmer. Three local participants mentioned the fact that now there were few sick people in local hospitals which indicated that the ecological situation in the region was good enough.

Many local interviewees agreed that due to climate change precipitation would decrease and aridity increase. All these, of course, would affect many spheres of life – population health, its economic activities, including agriculture and nature. In such a scenario we might need to adapt and switch to different crop cultivation, proposed one participant.

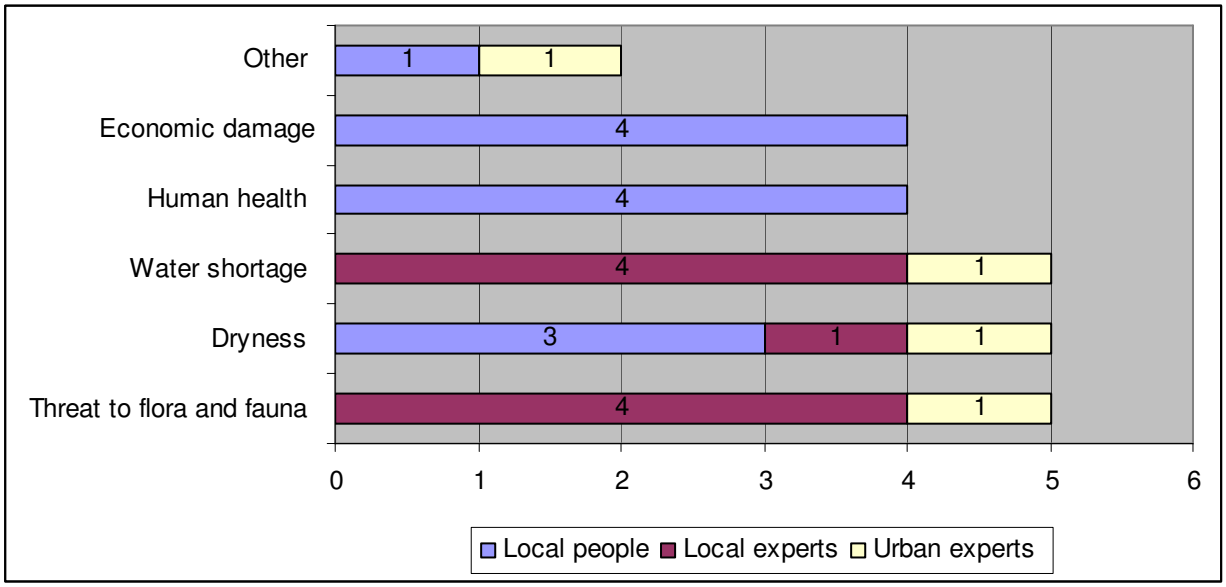


Figure 11. Interviewees' opinions regarding climate change in the study area, people.

5. Which are the main land uses in Lebap Velayat and where are they distributed?

The study area is located in Lebap Velayat which is one of the leading regions of the country producing agriculture outputs. During the interview, we asked people to tell us about main land uses in this region and where they were distributed. Out of ten local interviewees seven were farmers and only three were representatives of the local society: authority, Elder and Imam. All received answers were quite similar to each other. Generally, the farming system operates in three tiers- leasehold, household and private plots.

Leasehold plots: All farmers said that they leased lands from a peasant association (former collective farm) and planted a crop according to the contracts. Farmers mainly grow wheat and cotton for delivery to the state. In rare cases farmers also grow rice and fodder (lucerne and corn). Three interviewed farmers grew wheat and other three planted cotton. Only one farmer sowed both crops on the different lease plots. The areas of their leaseholds varied from 1 to 3 hectares. Representatives from the local authority said that this year their village (Kabakly) sowed 808 hectares of wheat and 810 hectares of cotton. One farmer said that before, people planted much cotton, but during the last 5 years they began to plant more wheat and rice. The President of the country declared that the main task of the agriculture sector is to provide the population with sufficient foodstuff. Two urban experts stated that around 90% of country's irrigated land was sown to cotton and wheat. During the Soviet Union period crop rotation was very strictly conducted, but this is not the case today, said one expert.

Household plots: All rural families have a small household plot of about 0.16-0.25 hectares on which they grow vegetables, fruits and garden-stuff and keep some private livestock.

Private plots: In addition to leaseholders and their household plots, Turkmen agriculture has another relatively new component of private form. These individual farms operate outside peasant associations on land grants received directly from the state. On these private plots people grow vegetables, rice, melons or specialize at the cattle breeding. Only one interviewed local farmers had a private farm where he grew vegetable.

In some places along Amu Darya river people plant mulberry as well. In the forest belt and the protected area agriculture was not conducted, said the staff of the Lebap Nature Protection Department that is responsible for nature protection in the study area. The agency observes the sanitary-protective zone which extends by 100 m along the whole length of river. Cattle breeding are conducted in a cultural zone and in a sandy zone (small cattle and cattle – outrun pastures).

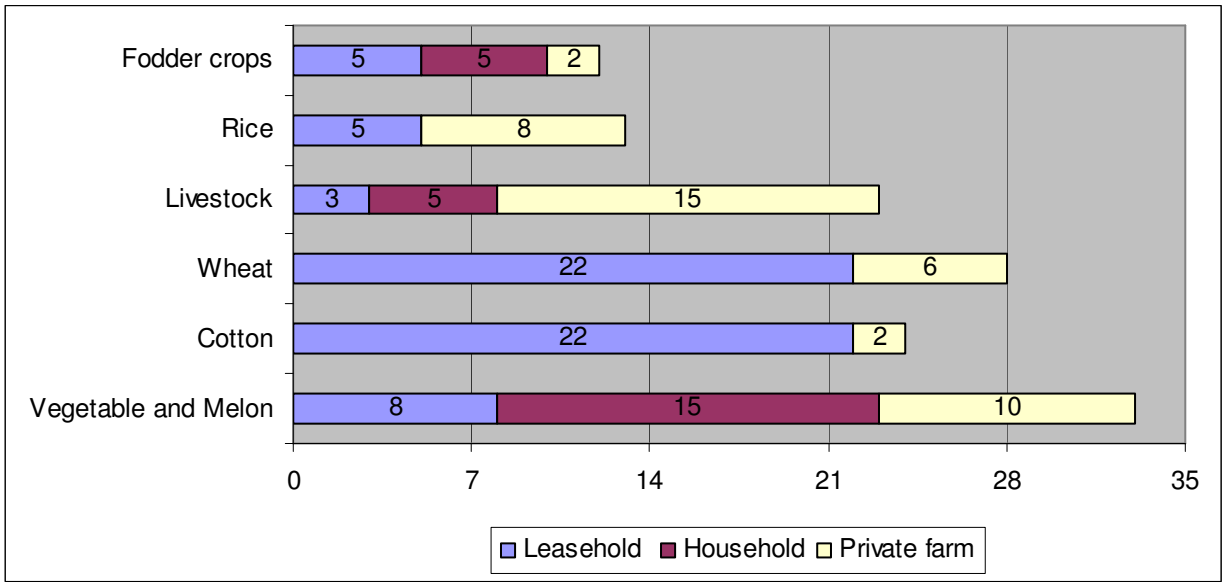


Figure 12. Interviewees' opinions regarding the main land uses in the study area, people.

6. How do the land users decide what to plant?

As it was mentioned before the farming system operates in three land use forms - households with fixed size of 0.16-0.25 hectares in villages and 0.04-0.08 hectares in cities; leasehold plot and private lands.

All respondents from both groups said that on the household plots people grow what they want to, basically for family needs such as vegetable, fruits etc. while on the leasehold plots people plant only according to state order – mainly cotton and wheat.

Actually, farmers conclude a contract with a peasant association in order to lease the land. This contract is valid for one year. The peasant association distributes its large fields to individual leaseholds and transmits state plans regarding the target crop. The state decides what to plant and how much yield should be delivered from the state fields. Thus, farmers grow only according to state orders i.e. what is stipulated in the contracts.

The representative from the Ministry of Nature Protection said that farmers started to grow rice and believed that this could solve soil salinization problems. Also, people plant poplar (*Populus*), oleaster (*Elaeagnus*) along the roads and lucerne after five-year cotton yield for a crop rotation. One farmer sharing his experience said that he grew wheat on the leasehold plot according to the contract and after handing it over to the state he planted rice for his own benefit on the same plot.

Why do people plant cotton?

In relation to this question all interviewees expressed their opinion differently. Summarizing these opinions three main types of answers were gained. People plant cotton for the following reasons:

State orders: Experts explained that the Government decides what priority to plant, i.e. which commodity has more demand. The strategic policy of our state is to plant cotton for export while wheat for own consumption. Cotton is considered '*White Gold*'. Cotton needed in order to provide the textile industry with raw material i.e. cotton. Many cotton-ginning, cotton-spinning factories and plants, and oil factories depending on cotton, provide work places for several thousand people. As for local farmers, they said that simply have to fulfill the state order and did not clarify this question any more.

Favorable climate: Some experts concluded that soil and climatic conditions of the country enable farmers to grow heat-loving plants including cotton. Farmers were also certain that due to the favorable climate they grew cotton and additionally to provide the textile industry with raw materials.

More profitable and convenient: Farmers were motivated to grow cotton because they gain from it more benefit than from growing wheat. In addition to the revenue from cotton, they received cotton seeds from which afterwards oil can be produced, the peel was used as fodder and used to make laundry soap and plant's branches could be used as wood. Comparing the economic profitability of 1 hectare of wheat and 1 hectare of cotton it was more profitable to plant cotton, said one employee from Amu Darya Nature Reserve who also leased land from the state. However, he added that expenses for cotton planting were high too – water, fertilizer, technical equipments, harvesting costs etc. Three representatives from the local community explained that it was convenient for their village to grow cotton.

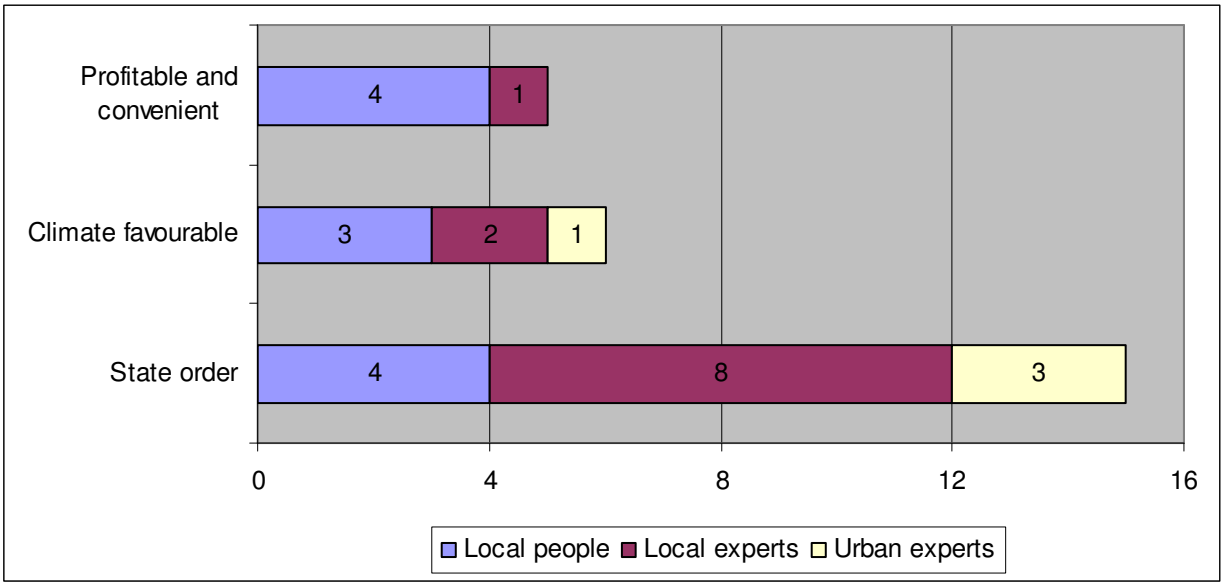


Figure 13. Interviewees' opinions regarding the decision on cotton cultivation, people.

Why do people not plant other crops and do people have the freedom to choose what to plant?

This question was raised in view of the cotton monoculture which has taken a place for a long time. Answers of both groups were monotonous and almost repeated the abovementioned statements.

Since 1991, according to the President's decree 1-2 or 5-10 hectares of land have been allocated to individual farmers for private ownership. On these private lands (mellek) and household plots people can

grow whatever they wish - wheat, rice, fodder crops, different kind of beans, vegetables, melon and greens. As for the leasehold plots, there farmers have to plant either cotton or wheat according to the contract signed with a peasant association. One respondent stressed that what and where to grow was decided collectively and altogether with the peasant association.

The decision of what and where to plant is made by the President of the country said one urban expert. In March, the 15th National Council was held where agriculture issues were considered. There the Head of Government decided how to distribute the agricultural crops, taking into account land, water and climate conditions. According to the state's decision, Lebap velayat has to plant cotton, rice and wheat as before. Thus, we can conclude that people have freedom to choose what to plant on the private land and household plots but on leaseholds there is no choice.

7. Where do farmers obtain the inputs from, seeds and fertilizers and also water?

State suppliers: Usually leaseholders use the standard range of purchased inputs and farm services, including seeds, fertilizers, mechanized fields services, and transport. State agencies and the peasant association are the main suppliers of all inputs and services. They are mutually complementary in their role as suppliers: some inputs are supplied primarily through state agencies (e.g., mineral fertilizers, herbicides, mechanized field services, seeds), while other inputs are supplied primarily by the peasant association (veterinary drugs and services, construction, consulting by experts).

The leaseholders fulfill state orders, therefore sources of agricultural inputs are the state agencies (Table 5). During the interview local farmers reported that everything was stated in the contract signed between a peasant association and individual or group of leaseholders. All terms, such as what to plant, how to process land, where from to take inputs and farm services from, working conditions and payments, are stipulated in the contract. Moreover, the contract states that "leaseholders shall conclude individual contracts with the State agencies (suppliers) which provide them with different services and inputs".

Table 5. State supplier of agricultural inputs

State supplier	Turkmen name	Inputs
Farm services	Turkmenobahyzmat	Techniques services such as combines and agriculture vehicles
Fetilizer Supply Service	Dokunchimiya	Fixed amount of fertilizers
Water Supply Service	Turkmensuwhojalyk	Water supply
Grain Board	Turkmengallaonumleri	Wheat seed
Cotton Board	Turkmenpagta	Cotton seed

Market suppliers: Local people on their household plots traditionally use cattle manure from their own stall or buy it at the market instead of using chemical fertilizer. As for water supply, the main water source is Amu Darya River and people use its water simply by digging from the nearest canals (irrigation ditch). For private plots people have to organize all agricultural inputs themselves. They purchase seeds, fertilizers and other stuffs in appropriate shops and on local markets.

Where do farmers sell their harvested crop to?

State markets: Leaseholders deliver their farm products to state marketers in accordance with the contract, i.e. to the Grain Board and the Cotton Board. These two agencies send their trucks to collect the harvested crop. The output of the two main products in leasehold farms, cotton and wheat, is sold in its entirety.

State marketing organizations are the dominant sales channel for these commodities, and the farmers reported that they have no option of choosing a buyer for cotton and wheat. The prices for the two main crop is fixed by the Government and farmers can not sell the harvested yield on their own decision. For one ton of wheat people get 270 Turkmen Manat (TM) and for one ton of cotton 1040 TM. If farmers planted cotton and wheat on the private plots they would have to sell their crops to the state at the same fixed prices.

Local markets: The household products are consumed by family and surplus is sold in local markets. Crops harvested in the private plots mainly for the trade and farmers sell it on the local bazars at liberalized market prices.

Do they pay for water, fertilizer, seeds and other inputs?

At the beginning of the planting period leaseholders receive all necessary inputs from appropriate state suppliers. Representatives from local authorities said that during the year they compile a document which describes all conducted activities both by a peasant association and a leaseholder. After the harvesting period, when the leaseholder delivers all crops, the peasant association's book keeper calculates the resulting costs and benefits. As stipulated in the contract, from the gained revenue the leaseholder has to pay off 3% to the Water Supply Service "Turkmensuwhojalyk" and 9% to the Peasant Association for provided services. The fertilizers, seeds and techniques (for ploughing and harvesting) are given out with 50% discount price. Expenses for provided services and raw materials are deducted from the total revenue. At the end, the net benefit in monetary value is assigned to the leaseholder's bank account in Daykhan Bank. If farmers grow cotton they have to pay wages separately to collectors who have harvested their cotton.

Since each soil has the respective water consumption norm (quota), only a fixed amount of water (10-20 m3/ha) is allocated free of charge. The charge of 3% from revenue is mostly for using pumps and services. Actually it is a very low payment and does not cover all expenses for water supply. For overused water farmers pay according to fixed prices. The same applies to fertilizers: only a fixed amount is allowed to be introduced into the soil, depending on the type of crop.

For household plots people withdraw water for free of charge. All interviewed people said that they never paid for water withdrawal for household plots.

8. What are the main constrains for land use?

Imperfect land use management: Among defined constrains for land use, many local experts mentioned problems which were related to imperfect land use practice such as the absence of crop rotation, irrational water utilization, shortage of inputs, misuse of technical equipments and sowing not according to climatic conditions. Concerning the local farmers, they mentioned mostly problems related to services of state supply agencies. Some of these were input shortage, lack and exhaustion of equipments (agriculture vehicles), delayed services, water supply and others.

Soil problems: The soil related problems was mentioned by a few interviewees. The expert from the Ministry for Agriculture noted that regrettably less than 0.3 hectares was available for 1 person when size of farms should be at least 30 hectares. Not only land deficiency was a problem but also its quality which was uncertain. The national expert from NIDFF comparing the current and the Soviet Union times said that before soil samples were taken every 500 m for chemical analyses but today nobody cares about soil quality. Nearly half of local farmers complained that the soil salinization constrained to receive high crop yield.

Climate and flooding: Natural events such as climate change and flooding also constitute constrains to land use practices. Flooding usually happens in the spring time and washes away the river bank where arable lands are mainly distributed.

Water scarcity: Another important problem, noted by some respondents, was water scarcity which directly reflects on quality and quantity of the crop yield. Some local farmers also pointed out water shortage in the Amu Darya River.

Low institutional capacity: The problem related to low institutional capacity was only highlighted by experts. It included the absence of a monitoring system for soil quality and the lack of scientific approaches in agriculture such as seed-growing institutes and experimental stations in the country.

No problem: Two local experts and two farmers said that there were no specific problems which constrained agriculture.

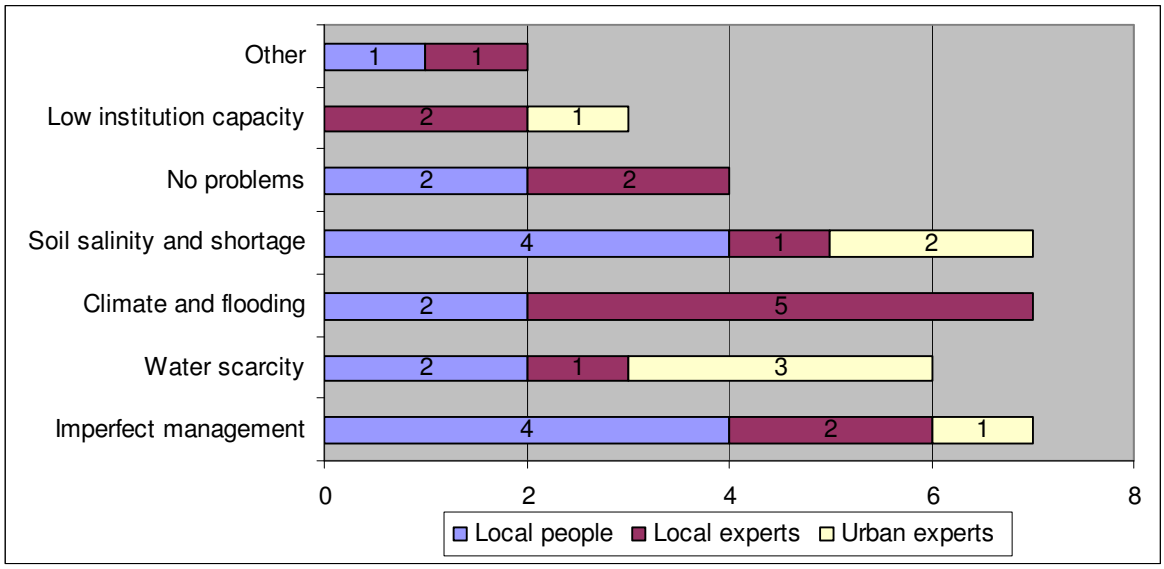


Figure 14. Interviewees' opinions regarding the agricultural problems in the study area, people.

9. Which impacts do the different land uses have on the environment?

Impact on the water resources: The experts said that impact on water resources i.e. on Amu Darya River was caused mostly due to irrational water utilization, pollution by different chemicals, return waters from the irrigated fields and water regulation (construction of different dams, canals and collectors). They explained that non-rational water use led to the rise of the ground water table which in turn caused soil salinization problems. More than 50 % of farmers stressed in the previous question that soil salinization were the most problematic issues for them. Not less damage caused water regulation performed in order to withdraw water for irrigation. For this purpose people dig many channels and change the river course.

Impact on the soil: Both experts and farmers reported impact on the soil which occurred due to the introduction of pesticides and other pest-killers. One farmer added that though pesticides polluted soil, to conduct agriculture without them was impossible. Furthermore, one farmer mentioned that soil quality and its fertility were being depleted from year to year due to the absence of crop rotation.

Impact on biodiversity: Impact on the biodiversity is related with the cutting down, fires and extinction of different species of flora and fauna. The director of the Amu Darya Nature Reserve ironically said "Now there is no forest remained and therefore there is no problem". Two farmers also agreed that due to land

cultivation people had to cut forests. In addition, one of them said that afterward agriculture did not bring any harm to environment.

Others: Three experts and three local farmers stated that there were no impacts on the environment due to agriculture and one farmer found it difficult to reply to this question.

10. How can the agricultural system be improved with regard to impacts on the environment?

Almost all national experts expressed many different suggestions with regard to an improvement of the agricultural system in the given area.

Crop rotation: Taking into account that agriculture was developing rapidly many specialists proposed to improve the soil fertility instead of an expansion of arable fields. Experts believed that crop rotation would undoubtedly increase soil quality (soil-conservation). Around half of all farmers also proposed to improve the soil fertility by introducing the crop rotation.

Scientific approach: Furthermore, many experts highlighted a necessity of the scientifically based approach in the agriculture system which should be applied in the current land use practice along with modeling and economic-mathematical methods. Such modern methods in agriculture could consider impact factors and propose some adaptation measures.

Water saving technology: In the view of water shortage some experts suggested to use the water saving technologies such as drip irrigation and to grow less water consuming plants. One respondent from the Ministry of Nature Protection believed that newly constructed Turkmen Lake could solve the problem related to the discharge of drainage water and reuse these waters for irrigation. Several farmers also expressed belief that the water saving technologies could increase water supply efficiency.

Others: Other suggestions to improve soil quality stated by experts were the introduction of more biological humus and preparations instead of the utilization of pest-killers (pesticides and herbicides). In regard to the land deficiency, one local people proposed to cultivate desert soils which were in abundance in the country. One farmer stated that farming people should use both water and land resources carefully. Three experts and two local people did not answer this question referring to the lack of necessary information.

11. How would you characterize the nature conservation situation in the past (end of USSR period) compared to today?

Positive situation: The opinions of the all national experts regarding this question were surprisingly unambiguous and decisive for making overall conclusions. According to the experts' statements the nature conservation situation has definitely improved during the last two decades. Since the establishment of the different nature reserves including Amu Darya Nature Reserve in this region nature protection has strengthened at a whole. Some of them said that Water Management Service («Suwhojalyk edara») conducted monitoring and carried out the chemical analysis of water along the river length on the territory of the country. Not less important part of nature conservation is the legislative base which has improved too during the defined time, said one urban expert.

Overall opinions of local people were also positive. Eight out of ten stated that the situation has changed positively. They mentioned the ongoing activities of the different organizations - the Amu Darya and Kugitang Nature Reserves, Repetek Biosphere Reserve and Forestry Green Belt ("Gok Gushak"). These organizations conduct nature protection and monitor the state of environment by forbidding the clear-

cutting, cattle gazing, fires, hunting etc. The Green Belt actively maintains forest ecosystems and organizes the community work days for planting trees inside and outside of the cities.

Others: Only one local expert said that a certain number of issues had been resolved during the last twenty years but other aspects had worsened. Two local people could not reply to this question.

12. What are the main constrains for nature conservation?

The expert group's opinion about the main constrain for nature conservation were split into two parts. Some experts considered that there are no problems for nature conservation while other respondents revealed problems related to financing, logistic, shortage of the specialists and equipments. One expert ironically cited that poachers were better equipped than rangers of reserves. He said that they were short of equipments for long distance controls, boats and helicopters in order to strengthen nature protection activities. Concerning shortage of human capacity issues, the experts connected it to the large area of monitoring territory. Actually, only 10 employees worked in each region and 20 in a reserve. One interviewee emphasized that the main difficulty was that the nature protection issues were not considered a priority problem on the Governmental level.

Other constrains listed by experts were agriculture growth, poor national legislation and fires. By cutting Tugai forests many arable lands were created, thereby causing a threat to animal and plant species. Furthermore, one specialist underlined that the national environmental legislation being an important instrument for nature conservation was imperfect. He stated that the national legislation should be improved taking into account issues of the current environmental condition and be in conformity with the international legislation.

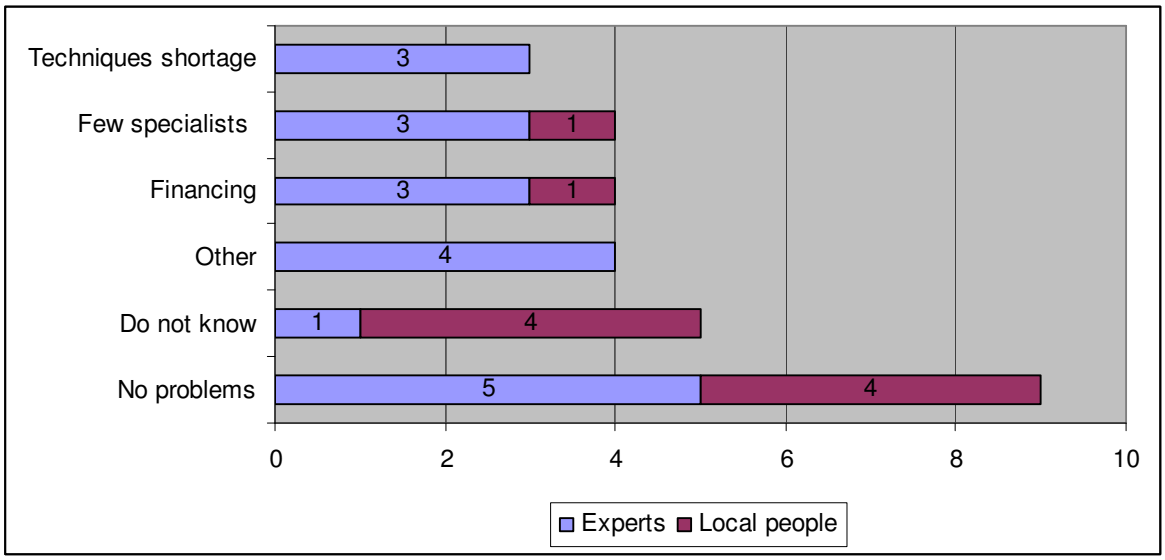


Figure 15. Interviewees' opinions regarding the main constrain for nature conservation, people.

The local people proposed three opinions regarding this question. According to the first perspective there are no problems for nature protection and no infringements. Local people said that they followed all rules and orders. They stated that the local population was interested in nature protection and assisted the reserve's rangers. The second part of interviewees could not reply to this question and only two respondents supposed that main constrains for nature conservation might be the financing shortage and lack of specialists, especially in forestry ("Gok Gushak"). For instance, local people including the school children and students were obliged to plant trees in certain periods of the year.

13. Are you concerned about the shrinking of Aral Sea?

Aral Sea desiccation brought many negative problems to social-economic and environment spheres for the surrounding regions. Amu Darya River failed to fill this sea due to the large-scale irrigation and it became the main reason for its shrinking. The question was raised in order to know how the people living in the study area think about this problem.

Expert's perspective: Almost all experts (85%) were very well informed and concerned about this problem. Truly, problems that occurred due to the Aral Sea shrinking negatively influence adjacent regions including the study area. The national specialists stated that the main problems were the contamination of environment and its negative effect on living beings. Water, soil and air are polluted by different salts, remains of pesticides, fertilizers, nitrates etc.

One expert said that around 300 years ago the Aral Sea had not existed at all and that the Amu Darya had flown into the Caspian Sea. However, the problems caused by its shrinking should indeed be solved because people faced water scarcity, and around 600 kg of salty dusts from the sea bottom are transported to the adjacent regions every year. Along with these problems, people experience climate change and complain about increasing aridity in the region, added other experts.

Local people perspectives: The local people reacted to this question differently. Around half of them were informed about Aral Sea related problems and expressed their concerns. In their daily routine people faced the consequences of this disaster in a different way. Some evidence was dusty winds and salty rains which negatively influence nature and people's health. Other local person said that they did not know about this problem and other said he never paid attention.

14. How could we contribute to saving the Aral Sea?

So far Aral Sea related problems are still under discussion among many national and international environmentalists. Despite undertaken efforts this problem is still not solved. These factors require developing the optimal solution taking into consideration not only the expert knowledge but also the perspectives of the local people living in this region.

New technology: The expert group considered that the solution of this problem could be new technologies such as drip irrigation which is widely practiced in different arid countries. Two local people also proposed the application of a water saving technologies which would decrease water demand and enable to allocate more water to Aral Sea.

Rational water utilization: A few specialists said that the solution was very simple: allocation of sufficient water into the Aral Sea. For that the water should be rationally used not only by peasant associations but by everyone in the kitchen and garden, stated one expert. Some local people also admitted that Amu Darya River should be used rationally and economically. They referred to some activities of local agencies which deal with water control and monitoring in the Lebap region e.g. Water Monitoring Service (Suwgozegchilik) and Mirap Service and expressed belief that such measures could contribute to save the sea.

No solution: One expert concluded that it is not possible to solve Aral Sea problem in this condition at whole due to its complexity. Another two experts expressed their worries about newly constructed dam in Tajikistan where Amu Darya originally flows from. They underlined that this circumstance would put additional pressure on the river waters. Countries located in the middle and downstream would suffer from water deficiency more than before.

Others: Other experts proposed different measures such as awareness raising campaigns about this problem, planting trees and shrubs and even breeding camels instead of bulls. Nearly half of the local people conceded that they do know how to contribute for saving the Aral Sea. Two experts also found it difficult to answer this question.

4.3. Environmental Situation

This section presents the current environmental situation of the study area, i.e. along the middle reach of Amu Darya River in Turkmenistan. This information has been retrieved through a literature review. To reveal the state of the environment the Pressure-State-Response Model was applied. The part "Pressure" shows the main driving forces for the environment of the study areas as root causes which limit regional development. The consequences of these pressures are described in the part "State". The part "Response" gives some suggestions to solve environmental problems in the study area.

4.3.1. Environmental Pressure

The main environmental pressures in the study area are the following:

- Water consumption including water intake to the Karakum Canal and water losses;
- Pollution of water, soil and air;
- Population growth;
- Deforestation, fires and overgrazing and
- Climate change

4.3.1.1. Water consumption

Naturally, Turkmenistan has very limited water resources and almost 80% of the land area is without surface runoff. Nevertheless, as in most countries, water use has increased over recent decades, due to population and economic growth, changes in lifestyle, and expanded water supply systems, with irrigation water use being by far the most important cause. For the period of 1970-2001 the main water consumer in the country has remained the agricultural sector (Table 6).

Table 6. Water intake and water use in Turkmenistan, 1970-2004 (Stanchin and Lerman 2005)

Years	Irrigated area, th.ha	Water intake mln.m^3	Water use by all users, million m^3	Agriculture %	Water use per ha irrigated land, th. m^3	Losses, % of intake
1970	668	12,738	10,276	98,2	15,1	19,3
1980	942	20,990	17,536	94,5	17,6	21,0
1990	1,239	22,435	19,800	87,7	14,0	22,6
1995	1,771	27,608	20,695	91,3	10,9	25,0
2000	1,793	24,917	17,430	89,7	8,7	30,0
2002	1,834	27,153	19,128	89,9	9,4	29,6
2004	2,200	27,958	19,251	88,8	7,6	31,1

In fact, irrigation practically covers the entire cultivable land in Turkmenistan. In 2001, the area of agricultural lands was 40.2 million hectares, of which 38.5 million hectares or 95.7% were the pastures, over 1.7 million hectares or 4.2% were the irrigated lands and 0.24% - perennial plantations (Table 7). Agricultural is a rapidly developing sector of Turkmenistan's economy. Between 1960 and 1994 irrigated land grew at a fairly constant annual rate of about 4%. The total irrigated area more than tripled in 35 years, increasing from 0.5 million hectares in 1965 to 1.7 million hectares in 2000. Irrigated land continued to grow after 1994, but at a significantly reduced rate of about 0.5% annually. By 2005 the irrigated area had exceeded 2.2 million hectares (Table 6).

The main source of water for irrigation in Turkmenistan and in the study area is Amu Darya River. The two most significant crops are cotton, which is grown on half of the country's irrigated land, and wheat. From year to year the state orders for crop grows which in turn leads to the enlargement of the irrigated fields and increase of water consumption. These facts consequently make a great pressure not only on the largest river of Central Asia but also on the unique Tugai ecosystem and its biodiversity.

Table 7. Water intake and water use by velayats of Turkmenistan, 2001 (Rajapov et al.2002; data from www.ecogeodb.com)

Velayats	Total land area		Irrigated land (th.ha)	Water intake, m^3	Water use by all users, mln.m^3	Agriculture %
	(th.ha)	%				
Balkan	13,927	28.35	509	927	303	30.1
Akhal	9,763	19.88	469	5,514	4,308	96.4
Mary	8,715	17.74	291	6,682	6,181	92.5
Dashoguz	7,343	14.95	271	6,798	4,573	99.7
Lebap	9,373	19.08	227	4,752	3,590	93.1
Turkmenistan	*49,120*	*100*	*1,767*	*24,673*	*18,955*	*92.2*

Table 10 illustrates that the Lebap Velayat compared with other velayats has the lowest fraction of water intake. The Dashoguz Velayat has largest fraction of water intake but relatively less area of irrigated land. Only Akhal Velayat has both high values of water intake and irrigated land. This Velayat located in the southern part of the country is the most populated area. It mainly uses water of Karakum Canal which is the major consumer of Amu Darya River. Annually, Turkmenistan can derive 22 km^3 or 36% of the whole flow of Amu Darya in compliance with the Interstate Agreement between the Central Asian countries. Almost half of this water withdrawal is allocated into the Karakum Canal.

4.3.1.2. Karakum Canal

The geographic position of the rivers and the direction of their flow do not coincide with the location of cultivable lands; the most fertile – and still insufficiently used - lands lie chiefly in the south, northeast, and west, whereas the principal rivers run mostly in the east. The construction of Karakum Canal was aimed at irrigating the southern part of the country. Started in 1954, and completed in 1988, the canal is navigable over much of its 1,375 km length (Rajapov et al. 2002). It carries Amu Darya water (Table 8) across the Karakum Desert in Turkmenistan and irrigates about 1 million hectares of agricultural land. The canal opened up huge new tracts of land to agriculture, especially to cotton monoculture heavily promoted by the Soviet Union, and supplying many cities with a major source of water.

Actual water intake from the Amu Darya River to Karakum Canal is almost 50%. Due to the water shortage in Amu Darya River in 2000 and 2001 the limits of water intake from Amu Darya were reduced for all users, including Turkmenistan (Table 8).

Table 8. Actual water-intake from the Amu Darya River by Turkmenistan (Rajapov et al.2002)

Year	water-intake, mln. m^3		
	total	to the Karakum Canal	
1997	21,146	10,687	50.5 %
1998	23,024	11,931	51.8 %
1999	22,045	11,118	50.4 %
2000	16,748	9,003	53.8 %
2001	13,519	7,171	53.0 %

Unfortunately, the primitive construction of the canal allows almost 50% of the water to escape en route, creating lakes and ponds along the canal, and a rise in groundwater leading to widespread soil salinization problems. The water lost from these canals through irrigation and from evaporation in the arid climate contributes to the shortfall of the Amu Darya and other streams in their lower courses. The canal is also a major factor leading to the Aral Sea environmental disaster (Kharin 2002).

The construction of Karakum Canal enabled to simply bring water to areas where the local people for ages used traditional irrigation methods. Thus, traditional knowledge of local circumstance and features were entirely ignored. The situation is aggravated by the fact that scarce water resources of the country are still supplied free of charge with improper irrigation system.

4.3.1.3. Water losses

A large share of water intake can be attributed to water losses as well. Water flow varies along the course of the river. Its variation depends on groundwater influx into the river in the zone of flow formation, return waters inflow into the transit area which varies according to water level, and flow losses in the lowest delta area. Some loss also occurs due to evaporation and filtration in reservoirs. At present, summary loss from reservoirs due to evaporation and filtration amounts to about 1.4 km^3 per year in the Amu Darya basin.

A considerable amount of water is lost along the course of the river (riverbeds). During the last five years, observations in this part of the river have shown that the losses vary considerably, from 7.0 up to 13.0 km^3 per year. This amount is comparable to 20-40% of total water intakes value to the canals. Even taking into account the losses due to evaporation, filtration and riverbed storage, there are huge imbalances. The reason for these high imbalances is unexplainable, as general climatic and hydrologic factors do not support them (data from www.cawater-info.net).

Major water losses account for 50-80 % of total water withdrawals (Nihoul et al. 2004), these being due to old and inefficient irrigation channel networks, inefficient irrigation methods, and no economic incentives for water saving. The efficiency rate of the irrigation system does not exceed 0.6. (Orlovsky and Orlovsky 2005).

Though the country's development is limited by water resources the value of water intake and water losses increase every year (Table 9). Evidently there is no technological progress at the moment. In 1970 the water losses accounted for 20% and then for 25 years it has increased by 5% and for 35 years by 10

%. Could it be possible to reach at least 1970s levels? Turkmenistan is not a poor country and has a lot of revenues from its natural resources.

4.3.1.4. Water pollution

Return water from irrigated fields, containing salts, pesticides residues, defoliants, and nutrients are the major pollution source in the Amu Darya basin (Table 9). In addition to pollution from the return flow, there is also contamination by industrial and municipal wastewaters. The water quality also deteriorates due to the general decrease of river runoff.

Table 9. Discharge of drainage waters into the Amu Darya river bed (Nihoul et al. 2004)

State	Drainage water discharge, km^3	Load salts, million tons
Tajikistan	0,4	2,0
Turkmenistan	2,8	7,3
Uzbekistan	1,2	12,0

In 1990-2000, on the territory of Lebap province 2.57-4.86 billion m^3 of drainage water was discharged to the Amu Darya from Turkmenistan and Uzbekistan (Rajapov et al.2002). In the Amu Darya delta region not only surface waters but also groundwater resources are affected by the extensive use of pesticides, defoliants and fertilizers. In the downstream region, maximum concentrations of 0.16 ppm (ground water) and 1.33 (soil) – cumulative value for insecticide and its metabolites (Nihoul et al. 2004).
Consequently, these problems led to the fact that communities throughout the region routinely suffer water pollution and shortages, which ruin crops and force up prices for staple foods.

4.3.1.5. Soil pollution

The concentration of pesticides and mineral fertilizers in the irrigated lands is the concomitant factor of their pollution. According to the data of the Ministry of Agriculture of Turkmenistan, over the last seven years (1995-2001) the application of pesticides, herbicides, defoliants and other chemicals has decreased 2.9 fold, and the area of their use has been reduced 4 fold (Fig. 16). In 2001, pesticides were applied on 194,400 ha for the whole country, of which 8% are the lands in Lebap province where around 1.08 kg of pesticides were used per hectare.

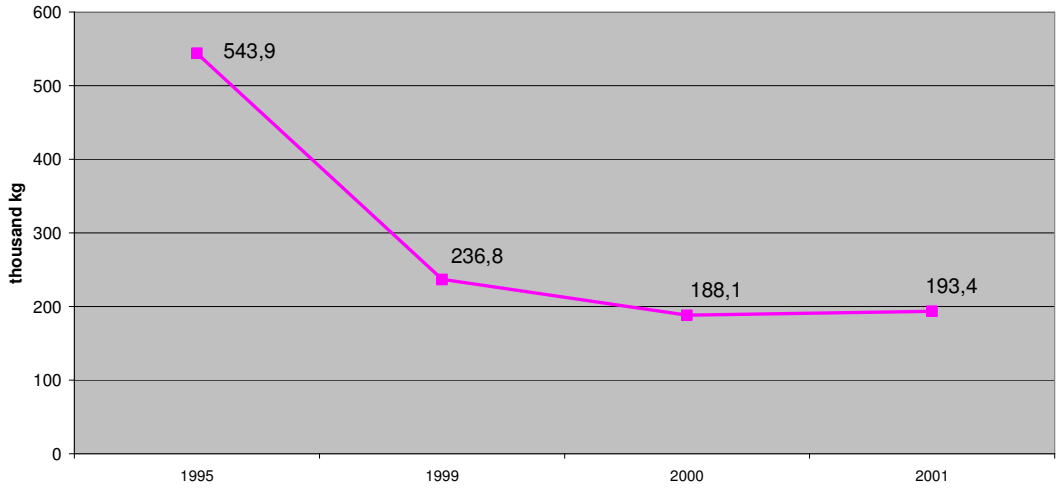


Figure 16**.** Pesticides volumes used during 1995–2001 in Turkmenistan, thousand kg (Rajapov et al.2002).

Anthropogenic factors of water and soil pollution are closely connected to the agricultural development of territories in arid climate. The increases of agricultural production were achieved primarily through increases in the cultivated area. Though cotton production has decreased by 50% times over the period from 1990 to 2005 the wheat cultivation has increased by 6 fold (Table 10). Therefore there is still overall growth of agriculture and all demand on water, amount of pesticides and pollution are still rising.

Table 10. Production of grain and wheat in Turkmenistan, thousand tons (World Bank 1992 -1996; Baydildina et al. 2000; Stanchin and Lerman 2003; Stanchin and Lerman 2005)

Crop	1990	1992	1996	1998	2000	2005
Grain	462,00	737,00	1106,00	1290,00	1759,00	2800,00*
Cotton	1457,00	1300,00	435,50	707,00	900,00	723,00

* data for year of 2004

The irrigation water of higher mineralization, with excessive amounts of toxic substances, is an additional source of soil pollution. This problem is especially acute in Dashoguz and Lebap Velayats. Together with other pollutants, about 600,000 tons of aerosols from the dried-up bed of the Aral Sea fall down annually to the territory of these provinces, and 70% of them fall to the irrigated farming zone.

4.3.1.6. Air pollution

It is caused mostly by ongoing industrial enterprises, energy sectors which compass the oil/gas sector and transport. The most affected region of the study area is Turkmenabad city, once included in the list of the dirtiest cities of the USSR. The average annual concentration of dust reaches 2 maximum permissible concentration. Sulphur dioxide and nitrogen dioxide quantities observed in 2000 also exceed the threshold line. The main contributors to air pollution there are the industrial enterprises such as Chemical Plant, Cotton-Processing and Oil-Expeller plants, as well as motor transport. The share of the motor transport is 64% of the total emissions in the city. Frequent inversions of temperature and weak winds contribute to air pollution in Turkmenabat city. The northern and northeastern blows of wind are most unfavorable for the residents of this city.

Table 11. Emission volumes to the air in provinces of Turkmenistan, thousand tons (National Institute of State Statistics 1998)

Velayats	1999	2000
Balkan	1318.2	922.2
Akhal	36.8	60.5
Mary	27.5	31.1
Lebap	15.4	11.4
Dashoguz	1.9	5.2
Total in Turkmenistan	*1404.3*	*1034,7*

In the rural area, the main contributor to the problem of air pollution is the excessive use of pesticides and defoliants in agriculture. Along with soil, the air is contaminated with different agrochemicals which negatively impact environment.

4.3.1.7. Population growth

More than half the population (55%) lives in rural areas, but only 5% of the country's agricultural land (2,2 million hectares) is cultivable. The remaining 95% of agricultural land in Turkmenistan is desert pastures. 38 million hectares fit only for flocks of karakul sheep and camels, not for human beings. Thus, despite the huge expanses and small number of people, the effective population density in Turkmenistan is very high: there is only 0.6 hectares of arable land per rural resident compared to 2.3 hectares in the Former Soviet Union. The population size is growing rapidly as well (Table 12). According to the National Institute for Statistic and Information, from 2001 to 2006 the population of Turkmenistan has increased from 5,369,000 to 6,746,500 people, or nearly 1.3 times. During the last 10 years it has increased by 1.9 million people or by 52 % (Stanchin and Lerman 2003). The per capita endowment of irrigated land accordingly increased from 0.5 hectares to 0.7 hectares during the three decades. High rural birthrates (37.6 per 1,000) put strong pressure on land resources (World Bank 1992 -1996). To meet the growing requirements of constantly increasing population of the country every year more and more food needs to be produced. If land resources of the country do not limit agriculture development, water is the rather essential limiting factor.

Table 12. Territories and population of Turkmenistan and Lebap Velayat (Lerman and Stanchin 2004; National Institute of State Statistics 2005)

Political setting	Territory, (th.km^2)	Population, (thousands)			
		1990	1995	2001	2004
Lebap	93.73	735	947*	1160	1334^
Turkmenistan	*491.21*	*3714*	*4587*	*5640*	*6500*

* data for year of 1996; ^ data for year of 2005

4.3.1.8. Deforestation

Anthropogenic factors in combination with severe climatic conditions bring about the reduction of forest areas. In the immediate past, along the Amu Darya River the area of Tugai forest amounted to 37,000 hectares (Gladyshev 1992). The area of forests tremendously decreased due to conversion into farm land. The main reason of that was the water abundance in the study area. According the obtained results of satellite analysis the total area of the Tugai forest is 3,352 hectares (Practical Project 2008). The loss of these unique ecosystems is almost irreversible because in the light of changing climate and soil, reforestation would not be possible. Indeed, today people plant trees but only around the big cities, not along the Amu Darya River where the dense Tugai forests used to exist. The restoration of this forest is important and urgent because it brings a lot of benefits to the people.

4.3.1.9. Fires and Overgrazing

Fires and overgrazing negatively influence tugai vegetation and inhabitants. Fires occur due to natural and man-made phenomena. This in turn leads to destruction of tugai ecosystem and its inhabitants. Degradation of the remaining tugai forests can lead to their full disappearance. Uncontrollable overgrazing of unlimited amount of livestock leads to degradation of many places both in tugai forests and in desert pastures. Within the protected areas, realization of these activities is strongly prohibited. However, no control and monitoring system outside of natural reserves is implemented. Therefore, this problem strongly needs to be addressed. Due to the lack of available information for Lebap Velayat, data about magnitude and frequency of these affects was not provided.

4.3.1.10. Climate Change

The latitudinal position of the territory of Turkmenistan is in the zone of non-tropical deserts, making the country rather vulnerable to climate changes. However, the main distinctive feature of Turkmenistan's climate is not hot sun and not excess heat but moisture deficiency. The mean annual temperature and precipitation trend for 35 years show that the mean annual temperature has increased by 1°C, while the amount of precipitation is gradually dropping down and for whole period has reduced approximately by 30 mm (Allaberdiyev 2006). These data were obtained from 48 meteorological stations which are observing weather, precipitation, air humidity and other climate parameters of Turkmenistan (Figure 17).

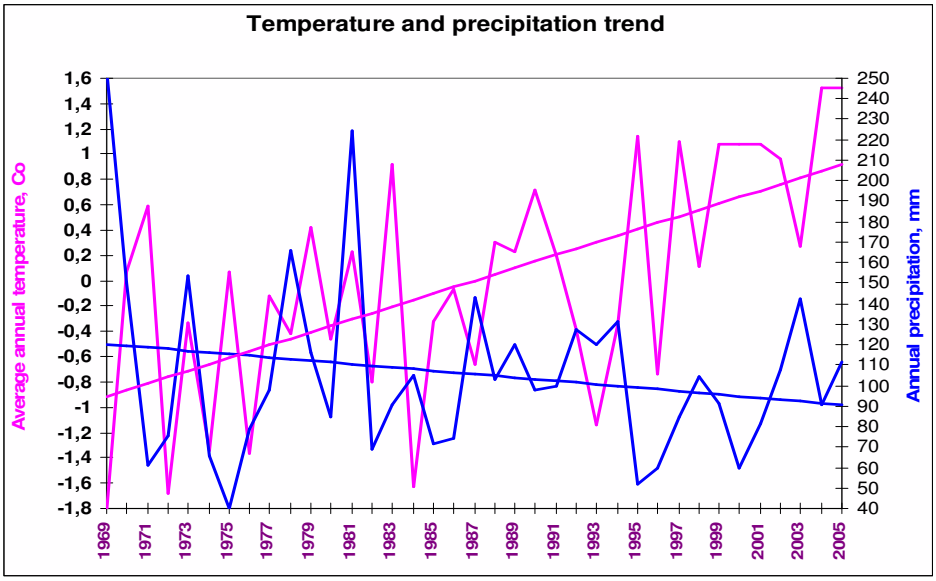


Figure 17. Trend of temperature and precipitation in Turkmenistan for 1969-2005 (Allaberdiyev 2006).

The Initial National Report on UNFCCC states that the Amu Darya River that provides needed water for prime agricultural areas would experience greatly increased flows during the first years due to the process of glacier melting. However, intensive global climate warming would subsequently cause changes in surface water resources. According to scientific predictions the glacier areas of Pamir-Altay, feeding the Amu Darya River would decrease by 40% in average by 2050 (Ministry of Nature Protection 1999). Aridity is expected to increase across the entire Central Asian region, but especially in the western parts of Turkmenistan, Uzbekistan, and Kazakhstan (Schluter et al. 2006).

4.3.1.11. The pressures on the Amu Darya State Reserve

Amu Darya State Reserve is located within the study area. The main objectives of the reserve are to protect the tugai ecosystems which remain only in this part of the country. By establishing protected areas in 1982 the state of tugai vegetation and its inhabitants substantially improved.

Meanwhile, the reserve is not fenced which enables local people to enter its territory from time to time. This leads to overgrazing, tree cutting, hunting and fishery. However, these interventions are not significant compared to influences coming from outside the protected zone. Overregulation of the river runoff, construction of flood protection dams, the operating of collector-drainage network, utilization of Amu Darya water for irrigation purposes, closeness of the irrigated fields to tugai forests cause disturbance of natural flood dynamics which are important for tugai vegetation development. Tugai

forests located in front of flood protection dams suffer from increased flood impact while the tugai forests located behind these dams are exposed to salinity and dry out due to the absence of appropriate washing by fresh waters. Partial salinity occurs in Amu Darya lower reaches in Aykhon Tugai Forest and partially in Nargiz Tugai Forest.

Sometime the animals inhabiting the reserve get outside of the protected areas. This raises poaching frequency, especially on ungulates (a deer, a wild boar, gazelle etc.). Some of these animals are rare and endangered, listed in the Red Data Book of Turkmenistan. The presence of invasive species is another danger for native fauna of the nature reserve. This phenomenon affects mostly fish species. A considerable share of them comprises acclimatized species. Among mammals, acclimatized species are nutrias and muskrats (Marochkina 2006).

4.3.2. Current State of Environment

Consequently the human-induced pressures lead to depletion of natural resources such as water resources, soil, air, biodiversity as well as worsen human health and economic downturn. Such trend of events in one region as a snow ball negatively effect the development of the region and the country's further economic growth. In our study area, abovementioned pressures on the environment and its different components have led to the following ecological problems:

- Water scarcity and Aral Sea desiccation
- Land degradation and salinization
- Poor water quality
- Low human health
- Droughts
- Desertification

4.3.2.1. Water scarcity

Water withdrawal to Karakum Canal, water losses due to evaporation and seepage, inappropriate irrigation network, extensive farming system, irrational water utilization, and climate change are the main causes of water scarcity in the whole Amu Darya region. As result, from the mid 1980s, water availability per capita has declined annually in Turkmenistan. With the permanent water intake of 25-26 billion m^3 per year from water sources, water consumption has decreased by 19% from 1996 to 2000, and in the year of 2000 it amounted to 3246 m^3 per capita (Fig. 18). With further population growth and the impossibility to increase the surface fresh water intake, water availability may decrease to 2134 m^3 per capita by the year of 2010 (Rajapov et al. 2002).

Amu Darya River is the most important river for the country and the whole Aral Sea basin. Areal expansion of irrigated agriculture was not so dramatic, but the impact of decades of water withdrawals from Amu Darya to irrigate cotton in particular have desiccated and polluted the lands bordering in the Aral Sea.

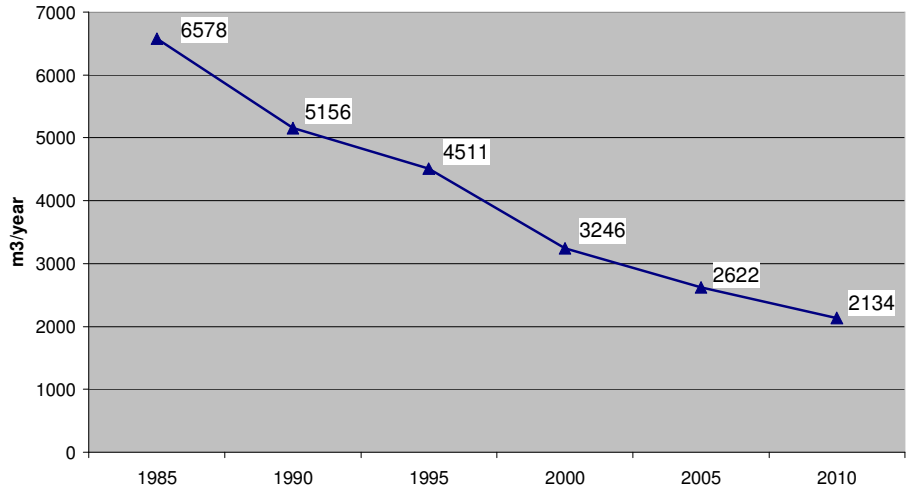


Figure 18. Water availability in Turkmenistan, m^3 per capita (Rajapov et al. 2002).

Amu Darya's average annual flow from the drainage basin is around 79 km^3 (Schluter et al. 2005). Due to the development of modern large-scale irrigation and significant water withdrawal to Karakum Canal, average inflow of the river to the Aral Sea has decreased considerably. Eventually less water of Amu Darya River flows to downstream regions (Table 13).

Table 13. Amu Darya River flow, km^3 (data from www.cawater-info.net)

	1965-1970	1971-1975	1976-1980	1981-1985	1986-1990
River flow at Kerki (Turkmenistan)	61,3	55,5	60,5	56,2	46,7
River flow at at Tuyamuyun (Uzbekistan)	44,7	37,4	38,3	32,7	18,4

4.3.2.2. Aral Sea Desiccation

The irrational use of water resources of the Amu Darya River by the countries of the Central Asian Region during the last 40 years is one of the most critical reasons of irrigation water deficiency. From 1960 to 1998, the surface of the Aral Sea shrank by approximately 60% and its volume by 80%. In 1960, the Aral Sea was the world's fourth-largest lake, with an area of 68,000 km^2 and a volume of 1100 m^3. The salinity has increased from 10 g/l to about 45 g/l. as of 2004, the sea's surface area was only 17,160 square kilometer or 25% of its original size. By 2007 the sea's area again had shrunk to 10% of its original size and salinity had increased to levels in excess of 100 g/l (data from www.wikipedia.org).
Within the last 10 years, 43 million tons of salt annually were carried over from the Aral Sea Basin to the territory of 1.74 million square kilometers damaging the adjacent agrarian regions. The sand-saline aerosols spoil the soil in oases and pastures. The drying up of the Aral Sea brought serious environmental problems to the territory of Turkmenistan: Dashoguz and some part of Lebap Velayat. The total area of this territory is more than 90,000 km^2 that include large cotton-growing regions of the risky farming zone. This resulted in the environmental crisis in the Aral Sea Basin, salinization of irrigated lands and decrease of their fertility (Rajapov et al. 2002).

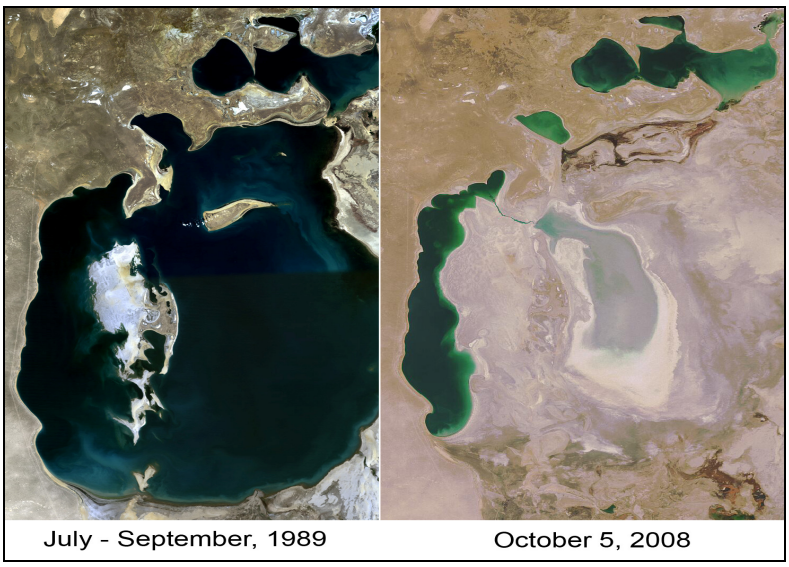


Figure 19. Map of Aral Sea (www.wikipedia.org).

Consequences of the environmental crisis in the Turkmen Aral Sea Zone are deterioration of irrigation water coming from the Amu Darya River, salinization of irrigated land with mineralized water, increase of water sources and soil pollution, loss of fish populations and the whole coastal flora and fauna, increase of transit drainage effluents in Daryalyk and Ozerny Collectors from the territory of Uzbekistan. This resulted in great social-economic damage to the population and economy (Ministry of Nature Protection 2000).

4.3.2.3. Poor water quality

Intensive agriculture implemented in the whole country has led not only water scarcity but also water pollution. Low quality of water caused mainly by usage of large amount of different pesticides and agro chemicals has negative impact on human health and different ecosystem. The maximum permissible content of soluble salts in irrigation water for plants and soil is 1.5 g/l. Water mineralization in the Amu Darya River varies within 0.6-0.84 g/l in summer to 1.8-2.4 g/l in winter. The analysis of the salt content in the Amu Darya River water shows the excess of chlorine and sodium ions. These are the most aggressive and toxic substances for all living beings. During soil leaching a large amount of salt enters the ground: more than 12.8 tons per 1 ha from 10,000 m^3 of water (Rajapov et al. 2002).

Table 14. Mineralization of Amu Darya River, g/l (data from www.cawater-info.net)

	1965-1970	1971-1975	1976-1980	1981-1985	1986-1990
Water mineralization, Kerki (Turkmenistan)	0.43	0.53	0.64	0.60	0.60
Water mineralization , Tuyamuyun (Uzbekistan)	0.44	0.58	0.78	0.95	1.06
Mineralization of drainage runoff	3.02	3.20	3.50	3.84	3.97

Below Tuyamuyun, another 1.6 million tons of salt are dumped into the Amu Darya. Water mineralization data in the two main cross-sections of the Amu Darya show that irrigation resulted in greater than permissible mineralization in the Tuyamuyun bed reaching up to 1.76 g/l already in the beginning of 1980s.

4.3.2.4. Land degradation

Irregular work of drainage on irrigated lands coupled with deterioration of irrigation systems and the whole infrastructure of water-management complex led to the rise of ground water levels, to soil salinization and its fertility reduction. According to the data of the National Institute of Deserts, Flora and Fauna, 446,000 km^2 of land (91.4% of the territory of Turkmenistan) are exposed to different forms of land degradation (Fig. 20). More than 68% of irrigated lands on the territory of the country are saline to the medium and severe extent (Ministry of Nature Protection 2000). About 36% of them are exposed to secondary salinization and waterlogging because of close bedding (up to 2 m) of ground water. This environmental problem is especially pressing for Dashoguz and Lebap provinces.

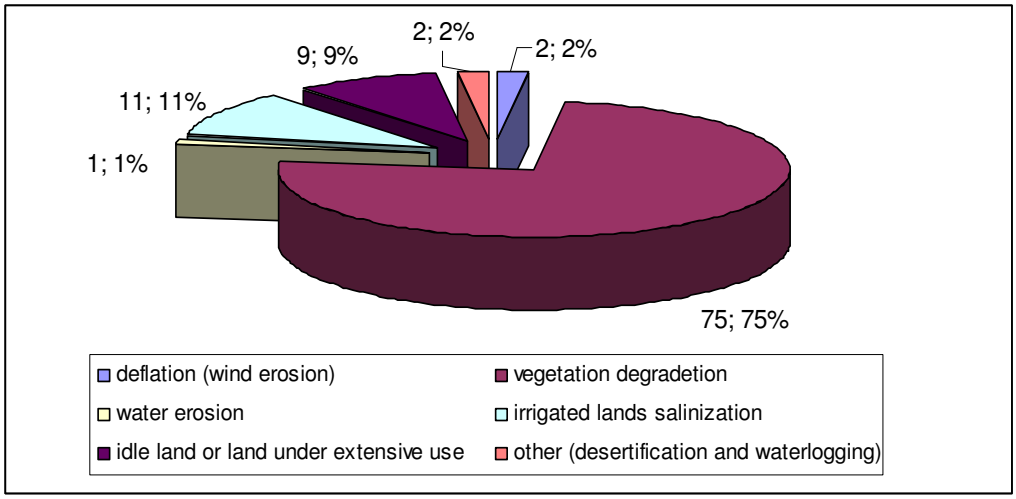


Figure 20. Land Distribution by Forms of Degradation (Rajapov et al. 2002).

Waterlogging spoiling the quality of irrigated lands depends on the state of the irrigation network. More than 90% of irrigation networks (interfarm and intrafarm systems) have been built in ground beds. The performance factor of such network hardly exceeds 0.6 causing water losses for percolation. This contributes, in turn, to the rise of ground water levels, particularly on territories adjacent to canals. Ground water rise and waterlogging processes on irrigated lands stem in no small measure from improper water application, breach of agrotechnical rules, faulty leveling resulting in water consumption increase. The total area of waterlogged lands in the irrigation zone is more than 650,000 ha. Waterlogging also appears in desert pastures of Karakum because of drainage water discharges. Today 698,000 ha of pastures are waterlogged (Rajapov et al. 2002). Although this figure is not very large, its environmental impact is rather serious.

4.3.2.5. Low population health

The main cause of low population health in the Lebap Velayat and its adjacent zone are air pollution, water pollution and Aral Sea shrinking. Pollutants of various kinds enter the atmosphere of industrial cities of Lebap Velayat such a Turkmenabad, Seydi, Kerki and others. These enterprises carry out oil-gas extraction, cotton proceeding, chemicals and mineral fertilizer production activities that have negative effects on the environment and human health. However, because of the insufficient control over these processes the respective institutions do not always have information on the content of pollutants in the atmosphere. The majority of these substances are very hazardous if their concentration exceeds certain threshold lines.

Up to 12.5% of respiratory diseases are connected with air pollution in the country (Rajapov et al. 2002). Chemical pollution causes an increase in the number of chronic bronchitis and bronchial asthma; it causes allergic effects in the human health and aggravates the course of pulmonary and cardio-vascular diseases, thus shortening the life expectancy. It is known that air pollution adversely influences physical and intellectual development of children. A direct correlation has been found between pollution degree and morbidity rate. Furthermore, the land around the Aral Sea is heavily polluted and people living in the area are suffering from a lack of fresh water and health problems, including high rates of certain forms of cancer and lung disease.

4.3.2.6. Droughts

As the territory of Turkmenistan is located in the depth of the Eurasian continent, far away from the ocean's mild influence, aridity and hot summers and frosty winters characterize the sharp continental climate of Turkmenistan. Droughts prevail all over the country with different numbers of days. In some areas, droughts occur for 10-30 days but in others for more than 70 days every year. Recent studies show that the drought frequency due to the climate change has steadily increased in many parts of the country (Ministry of Nature Protection 1999). The droughts combined with high temperatures constrain agriculture, forestry, and water economy development. Although officials maintain that wheat production for 2008-2009 will meet the country's needs, weather data and satellite imagery indicate a reduction of at least 0.4 million tons from last year's USDA estimate of 1.6 million tons, due to excessive dryness. Wheat production in Turkmenistan has been hampered for years by a crumbling infrastructure and limited inputs (www.pecad.fas.usda.gov).

4.3.2.7. Desertification

Environmental problems in the study area are tightly connected with agriculture as the main user of land and water resources. Land used in agriculture substantially is subject to the processes of desertification (Ministry of Nature Protection 2000). The causes of desertification involve a complex interplay of natural climate variability affecting drought patterns and unsustainable land use practices in drylands, which is further exacerbated by increased weather extremes associated with global warming.

Table 15. Degradation of desert pastures of Turkmenistan, km^2 (Rajapov et al. 2002)

Velayat	Degradation Degree			
	Weak	Moderate	Heavy	Total
Akhal	41,433	42,401	2,412	86,246
Balkan	43,116	43,583	6,470	93,169
Dashoguz	20,336	39,905	3	61,144
Lebap	44,428	26,766	2,007	73,201
Mary	46,982	22,153	5,461	74,596
Total (km^2)	*196,295*	*174,808*	*17,253*	*388,356*
Total (%)	*50.5*	*45.0*	*4.5*	*100.0*

Because of severe felling of forests and because of fires, waste land areas with thinned out vegetation appeared by the beginning of 1990 that led to soil and vegetation degradation, reduction of a number of water sources and their disappearance. First, small spots of desertification appear around water wells. Trampling down and eating of large amounts of biomass by livestock decreases plants communities'

productivity and changes their species structure. The most valuable fodder species gradually "fall out" of phytocenoses. Processes of vegetation degradation spread from these local spots of desertification increasing this area. Present-day degradation degrees of desert pastures of Turkmenistan are shown in Table 15.

Problems of land degradation are closely linked to poverty in Central Asia region, where it creates economic, environmental, and social hardship for millions of poor farmers who practice subsistence agriculture in fragile environments subject to periodic droughts and other desertification processes (Asian Development Bank 2009).

4.3.3. Response

Amu Darya River is vital and plays an important role for human beings and natural ecosystems of the entire region. Growing demand for water for irrigation, high levels of water pollution, and frequent droughts and widespread land degradation are among the key water-related issues not only for the Lebap Velayat but also for the entire Amu Darya region that already threaten human development and security. The core problem, however, is not the lack of water resources but rather their management and distribution.

Assuming that water shortages will continue to grow for whatever reason and population will continue to increase, what options are available for Turkmenistan and other countries with several million people (and still increasing) who are totally dependent on Amu Darya water for agricultural and domestic consumption? Against the background of climate change and shrinking Amu Darya river runoff, we have to raise the question of sustainable water management. Future water management will have to account for changing needs in agriculture, the demands of ecosystems in the deltas and littoral of the Aral Sea, potential increase in water intake from Afghanistan, effects of climate change, or other physical or socio-economic factors.

4.3.3.1. Government activities

Turkmenistan is actively seeking ways to alleviate its water problem. In the National Environmental Action Plan (Rajapov et al. 2002) water problems are a high priority issue of the Government. The NEAP suggests the introduction of water-saving technologies into irrigated farming; construction of water reservoirs; reconstruction of irrigation systems; their rigging with controlling hydro-technical facilities. The actions directed towards the solution of the water scarcity problem imply the following:

- increase of the efficiency of surface water use;
- introduction of cost-effective mechanism of water use;
- control of river flow (construction of new water reservoirs);
- provision of economic efficiency of investment projects.

The Turkmen government has started to introduce measures aimed at improving water use and reducing demand. One of them is "*Water Day*" which is aimed at increasing user awareness through the old Turkmen proverb – "A drop of water is like a drop of gold". More significantly, in May 1994 the President decreed that *water pricing* should be re-introduced. But while industrial users will pay for the actual volume of water used, agricultural users are to be fined for excess water use. Difficulties in monitoring and measuring water use and the lack of an organized body to handle the billing and collection of dues are hindering the implementation of water pricing today.

Another measure is the construction of the *Turkmen Lake*. The country is constructing a huge artificial lake in the middle of the Karakum Desert, on the site of a natural dry lake in the Karashor Lowlands. The lake is located at the border between Akhal and Dashoguz Velayats, some 350 km north of the capital Ashgabat. The lake will be filled with drainage water through two new collectors, the Great Turkmen Collector from the south and the Dashoguz Collector from the north, with combined length of over 1,000 km. Starting in 2009, the collectors will annually divert to the lake up to 10 km^3 of saline drainage water to the lake, which is currently discharged into Amu Darya. The lake's capacity will be 150 km^3, with a surface area of 3,500 km^2 and depth of 130 m.

It is argued by local water experts that the lake will reclaim 450,000 ha of waterlogged land, dramatically reduce the salinization of Amu Darya, and provide a huge reservoir of water that will be recycled for irrigation after partial desalination treatment. The exact nature of desalination is not clear at this stage, but Turkmen scientists are apparently working on bio-plateau techniques and harnessing of solar energy for desalination. If successful, these techniques will produce huge amounts of new water for irrigation and make it possible to double the irrigated area from its current 2 million hectares to 4-5 million hectares. There is a general optimistic vision to build up a huge oasis that will arise in the desert around the lake and along the new waterways.

However, potential side effects of this lake are still unclear. Indeed, the lake is part of a response strategy from the government's point of view. But is this really part of the solution or part of the problem?

Western experts working on the Aral Sea tragedy claim that the lake water will simply disappear through evaporation under the fierce desert sun, leaving salt sediments that will poison the entire area (Stone et al. 2008). The use of recycled lake water will only increase salinization of agricultural soils, as experience from other countries with the use of brackish water for irrigation has proved.

4.3.3.2. Conservation and sustainable water use

At the present time the optimal solution for water problems is revision of national water management strategies. Sustainable water management could be achieved only through a whole complex of measures such as:

- rehabilitation of traditional irrigation;
- shifting to commodities that consume less water (cotton trade-off);
- introduction of water pricing and
- application of water-saving technology

Rehabilitation of traditional irrigation

In order to find a solution for a problem it is important to explore its core source. In the case of the study area the main cause of water deficiency is the great Karakum Canal. The idea "to bring water to the desert and make it agricultural land" applied during the Soviet period consequently caused many ecological problems along with the Aral Sea disaster. Amu Darya River has failed to flow into the Aral Sea because of tremendous water discharge to the Karakum Canal with the purpose of large cotton cultivation. We have inherited this structure from the Soviet period and it is still there. After construction of the Karakum Canal the traditional irrigation system "Kyariz" (local name) used for many hundred years has been neglected.

Indeed, we can not suggest to remove the Canal because there are many cities and industrial enterprises along the canal which heavily depend on it. What we propose is to reduce the water which is diverted into

the canal and reintroduce the Kyariz system in the southern part of the country. Thereby, the amount of water which is needed for the Canal should be recalculated and reduced.

Today rehabilitation of the Kyariz system is important because this system represent one of the most ecologically balanced water recovery methods available for arid and semi-arid regions. Kyariz tap the groundwater potential only up to, and never beyond the limits of natural replenishment and, as a consequence, do not upset the hydrological and ecological equilibrium of the region. As the Kyariz often dug into hard subsoil, there is little seepage, no rising of the water table, no waterlogging, no evaporation during the transit – and hence no salinization in the area surrounding the conduits (Fig. 21). Moreover, Kyariz rely entirely on passive tapping of the water table by gravity only, whereas the extractive pumps consume an enormous amount of fuel per year (Reza 2009).

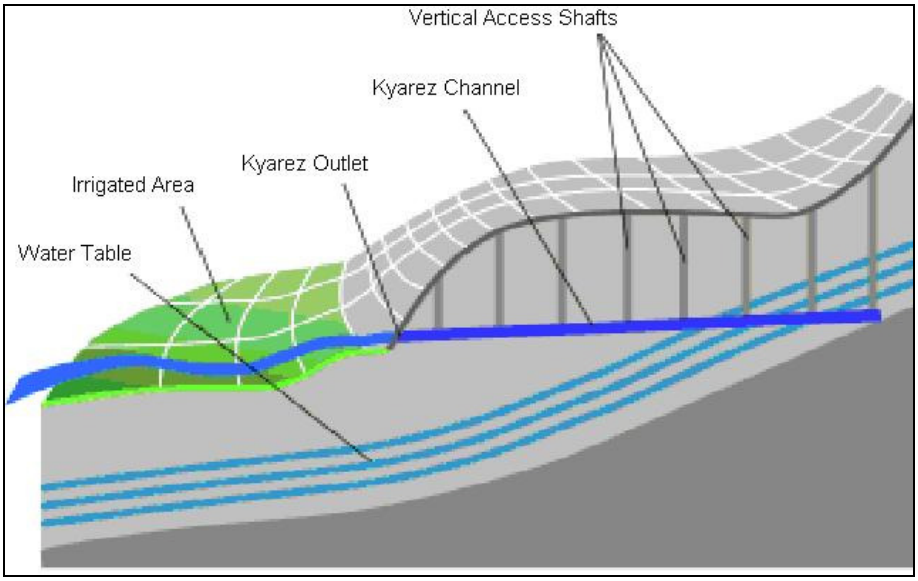


Figure 21. Kyariz underground irrigation system (www.wikipedia.org).

The Kyariz irrigation system rests on indigenous knowledge and experimental hydrology. It was widely used for several reasons. First, unlike other traditional irrigation devices, such as the counterpoised sweep, Kyariz require no power source other than gravity to maintain flow of water. Second, water can be moved over substantial distances through these subterranean channels with minimal evaporation losses and little danger of pollution. Finally, the flow in a Kyariz is proportionate to the available supply in the aquifer and, if properly maintained, these irrigation canals could provide a reliable supply of water for centuries (Reza 2009).

Kyariz are built by specialists who transmit their knowledge from father to son. A windlass is set up at the surface and the excavated soil is then hauled up in leather buckets. A vertical shaft of about three feet in diameter is dug out, one man working with a mattock and another with a short-handled spade. A gently sloping tunnel is thus constructed which conducts water from an infiltration section beneath the water table to the ground surface by gravity flow.

The Kopetdag foothill in the south of the country is the place where this underground irrigation system was widely used until Karakum Canal was constructed. More than 200 kyarizes operated prior to the October Revolution but nowadays they are ignored. Some part of them was disabled due to dropping

ground water after hydro constructions (Encyclopedia of TSSR 1984). Unfortunately modern water technology has deeply affected the way people perceive, value and use water.

Today the rehabilitation of the Kyariz irrigation system can only succeed with the help of modern technology. Modern mining technologies can be used to enhance the water efficiency of the Kyariz system, whereas water productivity can be improved by combining Kyariz and modern irrigation systems. Such a revitalization of the Kyariz system by modern technological means result in a substantial reduction of water intake from Amu Darya River. The interest for rehabilitation of the Kyariz system has revived in several countries already where ancient underground irrigation system has been declared as national heritage.

Water charging

In the pure economic theory the price is an indicator of the relative scarcity. Turkmenistan, compared with other Central Asia countries has very limited water resources of about 232 m^3 per person per year (Rajapov et al. 2002). Almost 80% of the land area is without surface runoff and it is covered by one of the largest sand deserts in the world. Water has always been considered as treasure in Turkmenistan and an old-time proverb "A drop of water is like a drop of gold" is proves this fact. Then why is it provided free of charge? Turkmenistan should review its policy of nonpayment for water and seriously consider the option of introducing water charges at least at the farm level. Today, irrigation agriculture is the main water consumer in the country. This is known to be an important economic instrument for minimizing wasteful use of resources.

The introduction of water pricing for irrigation requires the establishment of an appropriate institution dealing with water charging issues and placing water monitoring devices. However, these measures should be undertaken after arrangement of favorable conditions of payment for local farmers. At present, farmers can only grow what they are told and must sell their crop to the state at prices much lower than world prices. Given these factors farmers can simply not afford to pay large amounts for water.

If state control of the agricultural sector is phased out individual farmers should shoulder at least some of the burden. However, this should only be introduced as and when prices are liberalised and farmers are allowed to sell their products at world prices. Therefore, the government should firstly revise its payment strategy on revenues derived from agriculture and then introduce a water pricing mechanism.

Water saving technologies

Since nothing can be done about natural population increase and about the absolute limit on water intake from Amu Darya, the focus of attention is on adoption of water-efficient irrigation technologies, such as drip irrigation, subsoil irrigation, sprinkling, and others. It is hoped that water efficient irrigation technologies will reduce water consumption per hectare for a given level of yields and thus enable Turkmenistan to irrigate a much larger area with its limited water resources. According to some estimates, the irrigated area will double from 2 million hectares to 4-5 million hectares, increasing agricultural production by at least 30% (Stanchin and Lerman 2005). Thereby, a growing need for irrigation water in the future and water resource deficits will require undertaking a complex of urgent actions.

Since drip irrigation is expected to reduce water consumption per hectare by 30% to 50%, a careful economic and environmental impact analysis is required to compare the outlay with the benefits of higher yields per unit of water and lower salinization. It should be kept in mind however, that drip irrigation is not a panacea: while appropriate for cotton, which grows in orderly rows, it cannot be used on wheat fields, which have no row structure. Drip-irrigation hardware is highly sensitive to the quality of water:

the silted water from unlined open-air canals and ditches will quickly clog the drip irrigation lines, and even frequent maintenance and replacement of filters – in itself an expensive proposition – will not entirely solve this difficulty (Stanchin and Lerman 2005).

Cotton trade-off

People are looking for alternatives for natural cotton because of the problems associated with its cultivation: it is dependent on high amounts of water and the use of agrochemicals to ensure good yields. Despite its aridity, Turkmenistan develops its cotton industry for international export. As stated in the development program until 2020, the Government plans to establish new modern enterprises all over the republic. Over US$ 650 million will be invested in the textile industry.

During the last years, the price of cotton on the world market has dramatically dropped due to the competition among the countries. Today, cotton is grown in different parts of the world. Thereby, it is more likely that the decrease in demand and price of cotton will continue.

In background of climate change it is highly important to find an alternative crop to cotton. Cotton can be substituted by other crops which have a lower impact on the environment, less need for water and labor force. For instance, wheat uses 40% less water per hectare than cotton. According to 2004 data, wheat consumed 3,940 m^3 of water per hectare, compared with 7,040 m^3 per hectare for cotton (Stanchin and Lerman 2005). The shift from cotton monoculture to diversified wheat–cotton agriculture may contribute to the stabilization of water use. Scarce water resources should be used for the needs of the country's own population, but not for irrigation of cotton which is being exported to western countries. If the country continues to increase cotton production with its scarce water resources then in the near future this country will be obliged to import water resources which were improperly depleted.

4.3.3.3. Sustainable conservation and land use

The study area encompasses three state reserves; all of them belong to IUCN category I which means strictly preserved and direct human interventions is strongly prohibited. On the other hand, nearby territories are under heavy pressure of human activities, artificial systems e.g. Karakum Canal, and irrigated fields etc. High intensive land use and pure wilderness which should be untouched: unfortunately this combination is not sustainable in the long term.

The loss of biodiversity is recognised as a tremendous threat to ecosystems, but its maintenance is challenging. One important issue is seen as decisive for its success: the integration of sustainable use and conservation of biodiversity that means to reconcile protective measures with different kinds of use.

Tugai forests have an enormous importance for the world's ecosystems and thus for humans living in them. They provide ecological benefits such as biomass and carbon accumulation, due to their high productivity, prevent desertification, and cool the local climate. The plants' root systems strengthen riverbanks, preventing their erosion and landslips.

Reconciliation of high intensification and wilderness could be solution and well suited for the study area. Maybe more nature conservation aspects in irrigated systems and less strict conservation in protected areas. If people are not allowed to go to forests they can not enjoy, love and value it. The good practice advice the combination of area containing unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity and at the same time providing a sustainable flow of natural products and services to meet community needs.

4.3.3.4. Theory of Environmental Sustainability

All these measures – whether high-tech or conventional – need money for implementation. Turkmenistan should seriously consider options for increasing the budgetary allocations to water system maintenance and upgrading from its large cotton exports and natural gas revenues. The pattern of GDP growth in recent years shows that Turkmenistan can afford larger investments in its water management system. The country is rich in hydrocarbon fuel such as natural gas and oil. These resources are non-renewable and no one knows how long they will last. The theory of sustainability (Hartwick Rule) suggests that the current generation has been given an endowment. Part of this endowment consists of environment and natural resources and physical capital (such as buildings, equipments, technology etc). Sustainable use of this endowment implies that we should keep the principal (value of endowment) and live off only the flow of services provided. We should not exhaust the non renewable and scarce resources, cut down all trees leaving our future generation to fend for themselves. Rather, we need to assure that the value of the total capital stock is maintained, not depleted.
The stock of capital could be held constant by reinvesting all revenue from non-renewable resources in man-made capital (Hanley et al. 2002; Tietenberg 2006). In another words, if the stock of oil (a type of ‘natural’ capital) runs down, the stock of man-made capital is built up in replacement. This result is very important for development of the economics of sustainable development for the long-term welfare of people.

In our case the revenues from the non-renewable resources of the Turkmenistan could be used for truly sustainable land use management, particularly for an improvement of irrigation systems. Integration of an ecologically sound and traditionally used Kyariz system into the modern irrigation system would be the best solution to water problems in Turkmenistan. Realization of this idea in a highly participatory way would make Turkmenistan’s agriculture sustainable for the future.

5. Discussion

The given research aimed to explore and examine the problems and possibilities of a transition to sustainable water management in Turkmenistan. Today, there is a broad consensus that we are facing a growing global water crisis. Most people seem to be convinced that the main cause of the water shortage or water stress is population pressure coupled with industrialization and urbanization, and more recently, with global climate change and the disastrous combination of lower precipitation and higher evaporation.

A massive rise in the consumption of water, which went hand in hand with an increase in the contamination of this finite resource, was made possible by relatively recent technological advances in large water reservoir and canal-building, well-drilling and pump technology. Consequently, people started searching for technical solutions, and promote the design and development of more adequate or appropriate technologies like desalinization, drip irrigation, rain water capture and storage, and water-free toilets.

From the late nineteenth century until the 1970s, Russian industrialized economy was dominated by the vision and politics of what has been termed the 'hydraulic mission'. This mission, involving hydraulic mega-projects like gigantic dams and large-scale irrigation systems was inspired by the belief that nature, including water, can be controlled and should be subjected to the mastery of science and industry. It was assumed that arid regions like Turkmenistan could be industrialized by making the necessary water resource available through building canals, dams, pumping up groundwater and bringing it to remote regions in order to 'attack against the desert' (Obertreis 2008).

The main challenge confronting the country is how to continue the expansion of food production to meet future demands without imposing negative effects on the environment.

The negative water balance implies that no more new land can be brought under cultivation, and that the country is already facing a critical situation regarding the management of water resources and sustainable food production in existing cultivated lands. In view of the Aral Sea disaster the transition to sustainable water management is especially urgent not only for Turkmenistan but also for the whole Central Asian countries. The water crisis is expected to get worse in light of population growth and climate change (Ministry of Nature Protection 1999). In fact, water consumption has decreased by 19% from 1996 to 2000 and it is estimated that per capita water availability may decrease to 2134 m^3 per capita by the year of 2010 (Rajapov et al. 2002).

Environmental situation in the study area

The interview data conducted in the study area conclusively specify the current environmental situation, land use practices and some issues related to nature conservation. Insights derived from this evaluation could be used for making proposals for the future in regard to improvement of the current land use system. Two groups of people have been involved in the interview – experts and local people. Naturally, perspectives of the representatives were quite different between groups and within each group as well. Therefore, all revealed contradictions were analyzed in order to make final conclusion on specific matters.

The question about the environmental situation in the study area (question 1) was perceived by all respondents in different ways. Nearly all local people (80%) said the environmental conditions were quite acceptable and had improved. However, at the same time some experts (36%) reported that the pressure

on the environment had increased and there were a number of ecological problems. The rest of the experts (64%) also agreed with the local people and said that the overall situation was satisfactory.

Explanation: Two groups gave two contradicting answers - one group concluded that there were improvements and another emphasized a highly problematic development. But if we now suppose that there is only one real state of the world and environment, if we suppose that there are no two realities to which two groups refer than the reality is one but perceptions are many. It seems reasonable to assume that members of the two groups said things from different points of view and through different lenses. They focused on and emphasized different things. Maybe one compared the current situation to the past, while having other concerns about the future in mind. Therefore, the perspectives of the people were likely more comparative.

The local people compare the current situation to the past, but experts see the risk in the future. They have different time perspectives. Independently of the problem of honesty, the time perspectives are more crucial. Because the simple people say how life was twenty years ago and how life is now. Maybe living conditions have improved comparative to the past and people are glad about it. But experts have different time perspectives; they all see these improvements but also see that the future related risks are beyond the improvements and whether these improvements can be sustainable or not.

Characterizing the environmental situation comparing the past to today (question 2) 78 % of experts mentioned many human-induced pressures which still take a place in this region. The time frame was defined as the last twenty years, i.e. since the country has become independent. The use of mechanically-pumped wells was heavily encouraged as a result of the agrarian reforms after independency of the country, which broke up the large collective farms and redistributed land to the peasants. Agricultural targets set by the `Ten Years of Prosperity' plan changed water requirements. In fact, the area of arable fields has increased by nearly 4 times in the last 40 years, reaching 2.3 million hectares. Almost half of this area – 1 million hectares – has been added during the 15 years since independence (Stanchin and Lerman 2005). According to state plans the total amount of land under irrigation will have to increase further. Given that water supplies in Central Asia as a whole are already exhausted and that there is a possibility that Turkmenistan will be required to reduce the amount of water it withdraws from the Amu Darya, demand will clearly exceed supply (Ohara 1997).

According to the experts the most concerning problems was the reduction of the Tugai forests (43%) as result of the agricultural growth. Local people also admitted that the ecological situation has changed during the last two decades, they especially highlighted climate variation (30%) and its negative impact on the economic situation. Perspectives of other local people (50%) again came to the contrary conclusion: they considered that the environmental situation became better than before.

Explanation: Contradictions in the given answers likely occurred due to the misunderstanding of the question as in the case of local people. Some of them associated the improved environmental condition with the absence of sick people in hospitals. Surely human beings are very prudent and highly intelligent. There is a lot of life world knowledge, traditions and people can compare the state of affair. But it is not reasonable to count the absence of illness and diseases as real improvement of the state of environment.

With regard to the question about ecological problems and their sources (question 3) the perspectives of experts and local people were again were different. According to the analysis of the environmental situation in the study area (Pressure-State-Response chapter) the priority issue in the given region is water related problems such as water deficiency and its pollution which have negative effects on the different spheres of socio-economic development of the region. All interviewed experts confirmed these challenges. However, local people expressed two different perceptions: some of them agreed that they

experienced water pollution (30%) and scarcity (10%), climate change and low fish stock (30%), while 40% of them stated that there were no ecological problems and no harm to the state of environment.

Explanation: In order to explain this controversy we could simple argue that the experts are clever and local people are less aware. Experts are scientifically educated and they have more data and therefore experts might know better than the simple people who work in the village every day. But the local people have their own knowledge, experience and prudence. Actually, they are more in contact with nature working daily on the fields. Thus, in a more analytical way I would say that some local people were not very keen to be questioned and therefore were not totally honest to me.

In relation to the question about climate change (question 4) all respondents reported that it would indeed influence the surrounding nature. The experts emphasized that climate change in this region would impact flora and fauna (36%) and water resources (36%). The local people associated climate change with other problems like economic damage (40%) and impact on human health (40%). According to the climate change scenario the situation in the given region would deteriorate by increasing aridity and high temperature. Initially, it would cause glaciers melting and replenishment of water resources but later the situation would sharply change when glaciers disappear (Bates et al. 2008). While experts assumed the consequences of climate change for the future some local people have already experienced climate variation and indicated it answering the question 2, 3 and 9. For characterization of the environmental situation comparing the past to today 30% of local people indicated changing climate and 20% of local people state this phenomenon as the main ecological problem in the study area which negatively impacts on agriculture.

Challenges for sustainable land and water use

Based on the interview data (question 5, 6 and 7) the basic crops grown in study area were cotton and wheat. As it is known, these both crops demand large amounts of water, and to plant them in an arid country where water resources are the limiting factor of development is extremely unappropriate. According to farmers the Government undertakes various measures for stimulation of people to plant these crops. On household plots people often grow what is needed for a family. Not a large number of local people have private plots on which people basically can plant whatever they wish. However, poor quality of these lands requires much effort and capital investments to reclaim them, and farmers cannot afford that. All good lands suitable for irrigation belong to the state. Once a farmer concludes the contract he will be allowed to lease land free of charge but will be required to grow and attain target yields in selected crops, mainly cotton and wheat. Additionally, the state allocates all necessary inputs at 50% discount price which should be paid off after delivering the target yield. Furthermore, for water farmers pay only 3% from the total revenue, while for private farms they should pay according to the fixed price. The charge of 3% of the revenue is mostly for using pumps and services. Actually, it is a very low payment and does not cover all expenses for water supply. Individual farm units are relatively small: 2 to 3 hectares for most families. Therefore, over the next few years a large number of small-scale farmers will emerge, which will have considerable but not yet well-considered implications for farm and water management. Reduced restrictions on cropping patterns will result in significant changes in water requirements and irrigation scheduling.

On household plot water is free of charge. The given circumstance and the economic mechanism on leasehold plots do not motivate people for effective water utilization. Reduction of water discharge and introduction of progressive watering technologies is not stimulated by the state. Here we have a moral problem – is there a right to water for irrigation? Surely, human beings have a right to water for drinking and sanitation because it is a basic need for daily life. But a right to water for irrigation in the different

country varies and depends on technology, scarcity and natural resources that certain country has. It differs from country to country. In the case of Turkmenistan which has very limited water resources compared with other Central Asia countries and almost 80% of the land area is without surface runoff this answer is undoubtedly clear.

Economists say that there must be a price for water which indicates that water is a scarce resource and it is not infinite and there are no surpluses. Thereupon we have two main problems for sustainable water management in Turkmenistan. Firstly, should there be pricing for water and secondly, would the local people understand and accept this (under which conditions)? The introduction of water pricing will be problematic, as there is no way of determining how much water individuals use. However, relying on the peasant association's role as water user association would reduce this problem. Placing a water monitoring device at the farm gate would be inexpensive and effective and achieved quickly. The farmers themselves would then have the responsibility of distributing the water charges among the association members (O'Hara and Hannan 1999).

The results of evaluating question 8 showed that natural events like climate change and flooding (30%), and water scarcity (25%) were considered as the main constrains for agriculture. Both experts and local people assured that these problems directly reflect on crop yields. Additionally, some local people stated imperfect land management (40%) and soil salinization problems (40%). Local experts also agreed with these facts while urban experts stated other problems.

Explanation: Such different answers of the experts can be explained by one reason. Some urban experts working in Ashgabat reported mainly general problems referring to the whole country (low institution capacity and water problems) which would also take a place in the future (due to climate change). But experts working in the study area mentioned problems which were specified by local people.

Impact of land and water use

It is well known that *agriculture* accounts for a large part of human impact on environment and represents both threats and benefits for environmental conservation, depending on the form and intensity of land use. After a brief sketch of the history of land use systems we can conclude that rapid transformation in agrarian reforms negatively affected the state of environment. Some of its disastrous effects were salinity, sedimentation, pesticide contamination, diminishing hopes of replenishment and dangers of aging, collapsing dams, begun to appear not only in Turkmenistan but also in many other Central Asia countries. Over the past four decades, farmers and others close to the land have watched that water tables drop as one well after another dried up, and formerly fertile lands were inevitably taken out of production.

The interview data (question 9) enabled to reveal which impacts occur due to the land uses in the study area. During the interview nearly all interviewed experts outlined three problems caused due to agriculture – impact on water resources, soil and biodiversity. Based on their opinions the impact on water resources occurred because of hydro constructions (28%), water pollution (21%) and irrational utilization (21%) which in turn leads to high water level (7%). Concerning the local people's perspectives, some of them stated only the impact on soil quality.

Irrational water use or over-watering represents a major problem. Not only is water wasted, but it directly and indirectly reduces crop yields. Firstly, with the optimum soil saturation level exceeded, the crop is stressed and the plant damaged. Secondly, over-watering increases soil salinity with consequent loss in soil fertility and crop yield. Many farmers are not aware of this relationship. They hold to the belief that if a little water is good, a lot must be better. But this misleading belief "the more the better" is a common mindset and does not hold true in many cases (with food, medicine etc). In the case of "the more water

the better" in land use practice we have salinization. Therefore, local people often stressed soil salinization problems.

Amu Darya River serves as one of the water sources for the Aral Sea and for the Karakum Canal. Though the Aral Sea is the natural basin of the river, the Karakum Canal is man made. It is no surprise that the large scale irrigation along the river and Canal caused the desiccation of the Aral Sea. All experts were very much concerned about Aral Sea desiccation and agreed that the main reason for this disaster was anthropogenic activity. An additional challenge to this problem seems to be the newly constructed dam on Amu Darya River in Tajikistan where the river originally flows from. The experts said that this hydro contraction would be a decisive pressure on this river and countries located in the middle and downstream would either severely suffer from water deficiency or live in worse conditions. Only a few local people were aware of this problem, having complained about negative influences on the environment and on people's health.

Solution of the research problem

Summarizing all outputs of interview data we can conclude that some local people gave statements which contradicted the experts' perspectives. In one case, some local people explained situations in different time perspectives. In other cases, some likely did not understand questions and more obviously, some were not sincere to me. In the light of such phenomena I can not totally rely on my interview results but only partly and have to make up my own mind about the situation, where the problem is and what should be done. Since we have several hypotheses and different explanations we should rely on what the experts said because they were more honest and more concerned about the environmental situation in the study area.

According to the environmental state of the study area and expert conclusions, the water related problems, especially its scarcity, pollution, and inadequate water management are the priority ecological issues requiring an urgent solution in the nearest future. What should be done for sustainable water management? The interviewed experts have recommended as the optimal solution an introduction of water saving technologies in the study area (question 10), i.e. in Amu Darya region**.** Certainly, progressive watering technologies have a considerable price. Besides, many specialists consider non-traditional methods such as sprinkle and/or drip irrigation inappropriate in Turkmenistan at this time (O'Hara 1999; Stanchin 2005). These forms of irrigation are not only very expensive but difficult to maintain and require good quality water. Turkmenistan has neither the financial resources nor the skills base to build and maintain such systems at present. More significantly, as the waters of the Amu Darya are heavily laden with sediment, sprinkler nozzles and drip holes would be easily blocked, making maintenance of these systems both costly and time-consuming.

Given these facts the best solution is the Reflexive Water Management or rehabilitation of the traditional irrigation system which has been proposed in the Pressure-State-Response chapter. Restoration of the underground irrigation systems 'karez' historically used by people in the foothill regions would make it possible to reduce water intake to the Karakum Canal. This time-tested system would relieve the water stress in the Amu Darya region.

Regrettably, local knowledge and adaptive technology development have been neglected historically. However, knowledge coming from several sources was not complementary and did not reinforce in solving water issues locally.

Kyarizes are the traditional hydro constructions created for carrying the gathered ground waters out onto the earth surface. Kyarizes represent a unique and integrative system illustrating the use of indigenous

knowledge and wisdom in sustainable management of land, water, and agricultural biodiversity. As well as strong collaborative work, sustainable agricultural communities, usage of ground water resources according to the existing capacity, sustainable use of water resources, prevent desertification, sustainable drinking water for urban and rural dwellers. Under ecological perspectives we suggest to integrate this underground irrigation system into the modern approaches in the southern part of the country.

However, to implement such ideas into the practice we should take into account the modern circumstances of environment, people's life styles and their perspectives. We should also ask: would the old system be an acceptable solution and can one come back to it? Despite a series of debates in many countries on how old systems could be integrated into but not replace modern systems, the karez has already been rehabilitated in Iran, Egypt and other countries of the Middle East and North Africa region (Beekman et al. 1999; Reza 2009).

Kyarizes could be profitable for Turkmenistan as well because they were traditionally used by people for a long time. According to historical data, on the territory of Turkmenistan kyarizes have been constructed during the 5^{th} -2^{nd} centuries BC near Parfiya and Anew. Their fresh water is used as potable water by the rural population, and also for irrigation of small plots of land. Therefore, the kyariz irrigation system is not going back to ancient days, but to be a little bit critical against water supply scheme of the current period. By estimations of national experts in 1950, only on Kopetdag foothills there were almost 200 kyarizes, with a water volume of 2260 liters per second. In 1978, the kyarizes were reduced in number to 38, and the others remained under ruins. A few kyarizes remained in some parts of country.

The main cause of their reduction was that kyarizes were neglected due to easy accessibility of surface waters. Most of all, their disappearance is connected with the construction of the Karakum canal which has transported Amu Darya River water to those areas where kyarizes were once used. Modern water technology has deeply affected the way people perceive, value and use water.

What is required in addition to the restoration of the Kyariz system is its integration in a modern environment. The rapidly increasing demand for water due to population growth and agricultural expansion in Turkmenistan cannot be accommodated by Kyarizes only. Therefore, what is called for is a complementary system of all methods of water provision. Real reflexive modernism combines very old but good technology and with very new highly advanced technology. The reflexive modernism is about the prudent combination of the old things, not because they are old but because they are quite intelligent and time-tested, and new things as micro irrigation because they improve the situation. I think that very prudent complementary of old and new technology can solve the problem that we raised in this paper. This is a step out of one way modernism. This does not mean returning to the past; it indeed is something new. I think that environmentalists should consider the highly intelligent combination of the old and very new.

Realization of such an idea would require great financial efforts on behalf of the Government. Although under current economic conditions this would be difficult, the government could take a number of measures to ease the situation. Meanwhile, pure economic sustainability theory suggests sustainable use of natural resources. It is widely accepted all over the world as the reasonable strategy dealing with exhausting resources. Most economic theorists say that the revenue from exhaustible resources must be invested into renewable sources of energy, and sustainable use of natural resources i.e. natural capital. In the case of Turkmenistan the reasonable investment would be in sustainable water management and thereby sustainable land use. If the country adopted a more reflexive and integrated water management approach there would be no reason why agriculture should not flourish in Turkmenistan as it has done in the past.

6. Conclusion

As a result of the construction of irrigation structures, and especially of the Karakum Canal, the hydrological balance of the country has changed, with more water in the canals and adjacent areas and less in the Amu Darya River and the Aral Sea Basin. This resulted in an huge increase in cotton area with its associated industry, at the cost of the rapidly shrinking Aral Sea, advancing desertification, and concerns over potable water.

Turkmenistan's land use history and future perspectives on land use show that rapid expansion of the agriculture sector has started during the Soviet Union period and will continue. If the strategy of the Soviet Union aimed at cotton, the strategy after the independence in addition to cotton focuses on grain self-sufficiency. According to some estimates, the irrigated area will double from 2 million hectares to 4-5 million hectares, increasing agricultural production by at least 30%. However, the expansion of the agricultural sector is not without costs. The results given in this paper confirmed that a highly inefficient irrigation system, as well as a vast area of land that had been degraded by decades of agricultural mismanagement. Thus, the question also has to be risen whether Turkmenistan has to self sufficient with regard to grain.

Through the Pressure-State-Response Model we reveal that the main environmental pressure in the study area is high water consumption and losses which resulted in the Aral Sea disaster, reduction of Tugai ecosystems and many other ecological problems. All interviewed experts expressed a great concern about the state of Tugai forests which were destroyed directly in order to gain new farmland and indirectly as a consequence of excessive use of the water resources for irrigation, i.e. dropping groundwater levels and decreasing river run-offs.

The deterioration of the state of irrigated lands and ecological conditions of adjacent oases lands can be explained not by the deficiency of water resources in Amu Darya River, but only by irrational use of the latter. Today water is the basic resource limiting agriculture development. Therefore, the main challenge confronting the country is how to continue the expansion of food production to meet future demands without imposing negative effects on the environment. A growing need for irrigation water in the future and water resource deficits will require undertaking a complex of urgent actions. In the given paper we proposed the complex of the different measures such as water charging, shifting to crops to that consume less water and water-efficient irrigation technologies and with more focus on the Reflexive Water Management.

At present, the best solution of all water related problems would be the integration of the traditional irrigation technology into the modern water supply system. The Kyaris is illustrating the use of indigenous knowledge and wisdom in sustainable management of land, water, and agricultural biodiversity. This underground irrigation system was used in the southern part of the country for water from Kopetdag but largely abandoned in favour of wells and the use of motor pumps to extract water. But pumping is a short-term solution that creates a long-term problem – the drying up of groundwater due to over-pumping. Integration of old irrigation system would be the decisive solution of the present problems.

The reintroduction of the Kyariz system would some extent alleviate the water consumption through Karakum Canal. Kyariz do not upset the hydrological and ecological equilibrium but in contrary solve

many ecological problems and represents sustainable use of water resources. They present one of the most ecologically balanced water recovery methods available for arid and semi-arid regions.

Thus, Kyariz in a combination with artificial irrigating systems would play the important role in sustainable water management. Proposed water management system can be a basis for discussion and evaluation of future management alternatives. An integrated system will facilitate the restoration of natural ecosystems by supporting a participatory process.

Reference List

Allaberdiyev, K. (2006). Preparation of the Second National Communication on UNFCCC Initial Workshop on the Second National Communication on UNFCCC. Ashgabat, Ministry of Nature Protection.

Altunin, S. T. (1951). Гидрогология дельты реки Амударьи. Leningrad, Gidrometeoizdat.

Ashirova, A. A. (1964). Растительность долины и дельты Амударьи и ее хозяйственное значение. Ashgabat, Science Academy of Soviet Socialist Republic of Uzbekistan, 58 pp.

Ashirova, A. A. (1971). Растительность долины и дельты Амударьи и ее хозяйственное значение. Ashgabat, Ylym.

Bates, B. C., Z. W. Kundzewicz, et al. (2008). Climate Change and Water: Technical Paper of the Intergovernmental Panel on Climate Change. Geneva, Intergovernmental Panel on Climate Change.

Baydildina, A., A. Akshinbay, et al. (2000). "Agricultural Policy Reforms and Food Security in Kazakhstan and Turkmenistan." Food Policy **25**(6): 733-747.

Beekman, C., P. C. Weigand, et al. (1999). Qanas in Spanish colonial western Mexico Old World Irrigation technology in a New World Context. London, Portland Press. **73:** 440-446.

Driessen, P. and R. Dudal (1991). The Major Soils of the World. Wageningen, Agriculturral University Wageningen.

Encyclopedia of TSSR (1984). Энциклопедия ТССР. Encyclopedia of Soviet Socialist Republic of Turkmenistan. Ashgabat, Chief Editorial Office of Turkmen Soviet Encyclopedia. **1:** 394.

Gladyshev, A. I. (1992). Тугайная растительность Амударьи: современное состояние, экология, продуктивность, охрана и рациональное использование. Ashgabat, Ylym.

Glantz, M. H. (2003). "Water, climate, and development issues in the Amu Darya basin." Springer(10): 23-50.

Gries,D., Zeng,F., Foetzki,A., Arndt,S.K., Bruelheide,H., Thomas,F.M., Zhang,X.M. & Runge,M. (2003). Growth and water relation of Tamarix ramosissima and Populus euphratica on Taklamakan desert dunes in relation to depth to a permanent water table. Plant, Cell and Environment, 26: 725-736.

Hanley, N., J. Shogre, et al. (2002). Environmental Economics in Theory and Practice. Bristol, Palgrave Macmillan, 464 pp.

Kharin, N. G. (2002). Vegetation degradation in Central Asia under the impact of human activities. The Netherlands, Kluwer Academic Publishers, 376 pp.

Kulmatov, R. (2007). Modern Problems in Using, Protecting, and Managing Water and Land Resources of the Aral Sea Basin. NATO Advanced Research Workshop on Environmental Problems of Central Asia and their Economic, Social and Security Impacts, Tashkent, UZBEKISTAN, Springer.

Lerman, Z. and I. Stanchin (2003). New Contract Arrangements in Turkmen Agriculture: Impacts on Productivity and Rural Incomes. Central Eurasian Studies Societies Annual Conference. Harvard University, Harvard University.

Lerman, Z. and I. Stanchin (2004). "Institutional changes in Turkmenistan's agriculture: Impacts on

productivity and rural incomes." Eurasian Geography and Economics **45**(1): 60-72.

Lewis, R. A. (1966). "Early Irrigation in West Turkestan." Annals of the Association of American Geographers **56**(3): 467-491.

Marochkina, V. (2005). Описание полигона "Амударья" приоритетного участка ЭКОНЕТ. UNDP Project ECONET. Ashgabat, Ministry of Nature Protection**:** 41 pp.

Marochkina, V. (2006). Амударьинский государственный заповедник. Nature Protected Areas of Central Asia. R. Jashenko. Almaty, IUCN WESCANA in collaboration with IUCN WORLD COMMISSION on Protected Areas and Tethys Scientific Society**:** 219-225.

Ministry of Nature Protection (1999). Red Data Book of Turkmenistan, Ashgabat: Turkmenistan. Flora. **1:** 371.

Ministry of Nature Protection (1999). Red Data Book of Turkmenistan, Ashgabat: Turkmenistan. Fauna. **2:** 277.

Ministry of Nature Protection (1999). Turkmenistan: Initial National Communication on Climate Change. UNFCCC, The Ministry of Nature Protection of Turkmenistan. **1:** 89.

Ministry of Nature Protection (2000). National Action Programme to Combat Desertification in Turkmenistan. NIDFF, The Ministry of Nature Protection. **1:** 35.

Muller, H. (1994). Turkmenistan. Washington, The International Bank for Reconstruction and Development/The World Bank.

National Institute of State Statistics (1998). Environment protection and use of natural resources in Turkmenistan in 1997, Ashgabat, Turkmenmillihasabt.

National Institute of State Statistics (2005). Statistical Yearbook of Turkmenistan 2000-2004. Ashgabat, National Institute of State Statistics and Information of Turkmenistan**:** 216 pp.

Nihoul, J. C. J., P. Zavialov, et al. (2004). Dyinig and Dead Seas: climatic versus anthropic causes. Dordrecht, North Atlantic Treaty Organization. Scientific Affairs Division.

Obertreis, J. (2008). Der "Angriff auf die Wuste" in Zentralasien Zur Umweltgeschichte der Sowjetunion. Osteuropa. M. Sapper, V. Weichsel, M. Breuer and O. Radetzkaja. Berlin, Berliner Wissenschafts-Verlag. **4-5:** 37-57.

OECD (2009). Using The Pressure-State-Response Model To Develop Indicators Of Sustainability Paris, OECD Environment Division**:** 11 pp.

Ogar, N.P. (2003). Vegetation of river valleys. In: Rachkovskaya,E.I., Volkova,E.A. & Khramtsov,V.N. (Eds.), Botanical geography of Kazakhstan and middle Aisa (Desert region), pp. 313-339. Saint Petersburg: Komarov Botanical Institute of Russian Academy of Sciences, Institute of Botany and Phytointroduction of Ministry of Education and Science of Republic Kazakhstan & Institute of Botany of Academy of Sciences of Republik Uzbekistan. 339 pp.

O’Hara, S. L. (1997). "Irrigation and land degradation: implications for agriculture in Turkmenistan, central Asia." Journal of Arid Environments **37**(1): 165-179.

O'Hara, S. L. and T. Hannan (1999). "Irrigation and water management in Turkmenistan: Past systems, present problems and future scenarios." Europe-Asia Studies **51**(1): 21-41.

Orlovsky, L. and N. Orlovsky (2005). Water resources of Turkmenistan: Use and conservation. Israel, The Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev,

Sede Boker Campuc**:** 19 pp.

Orlovsky, N. S. and Z. I. Volosyuk (1974). Агроклиматические ресурсы Туркменской ССР. Leningrad, Gidrometeoizdat. 245 pp.

Ovezmuradov, G. (2008). Улучшение ирригационных систем Туркменистана. Ashgabat, Turkmen Water Research and Design Institute “Turkmensuvylymtaslama” of the Ministry of Water Economy**:** 5pp.

Practical Project (2008). Distribution of Tugai Vegetation along the Amudarya River, Turkmenistan. Greifswald, Ernst-Moritz-Arndt University of Greifswald: 12 pp.

Rajapov, M., A. Shamuradov, et al. (2002). State of Biological Diversity of Turkmenistan. Turkmenistan, The Ministry of Nature Protection of Turkmenistan/GEF. **1:** 128 pp.

Rajapov, M., A. Yazkuliyav, et al. (2002). National Environmental Action Plan. Ashgabat, Ministry of Nature Protection**:** 235 pp.

Reza, M. B. (2009). "Reflexive Water Management in Arid Regions: The Case of Iran." Environmental Values **18**(2009): 91-112.

Rustamov, A. and E. Rustamov (2007). Biodiversity conservation in Central Asia: on the example of Turkmenistan. Japan, Nagao Natural Environment Foundation. 96 pp.

Schluter, M., A. G. Savitsky, et al. (2005). "Optimizing long-term water allocation in the Amudarya River delta: a water management model for ecological impact assessment." Environmental Modelling & Software **20**(5): 529-545.

Schluter, M., N. Ruger, et al. (2006). "TUGAI: An integrated simulation tool for ecological assessment of alternative water management strategies in a degraded river delta." Environmental Management **38**(4): 638-653.

Schults, V. L. (1965). Реки Средней Азии. Leningrad, Gidrometizdat. 256 pp.

Smith,S.D., Devitt,D.A., Sala,A., Cleverly,J.R. & Busch,D.E. (1998). Water relations of riparian plants from warm desert regions. Wetlands, 18: 687-696.

Stanchin, I. and Z. Lerman (2003). Agrarian Reforms in Turkmenistan. Israel, Rehovot: The Hebrew University of Jerusalem, Center for Agricultural Economic Research.

Stanchin, I. and Z. Lerman (2005). Water in Turkmenistan. Jerusalem, The Hebrew University of Jerusalem, the Center for Agriculture Economic Research, the Department of Agricultural Economic and Management**:** 19 pp.

Stone, R. (2008) "A New Great Lake or Dead Sea?" Science. **320**:1096.

Thevs, N., S. Zerbe, et al. (2007). "Productivity of reed (Phragmites australis Trin. ex Steud.) in continental-arid NW China in relation to soil, groundwater, and land-use." Journal of Applied Botany and Food Quality **81**: 62-68.

Thevs, N., S. Zerbe, et al. (2008). "Structure, reproduction and flood-induced dynamics of riparian Tugai forests at the Tarim River in xinjiang, NW China." Forestry **81**(1): 45-57.

Tian,Y. (1991). Tokai on the delta at the lower reach of the Keriya River - a natural vegetation complex reflecting ecological degradation. In: Jäkel,D. (Ed.), Reports on the "1986 Sino-German Kunlun-shan Taklamaklan Expedition", pp. 99-112. Berlin: Gesellschaft für Erdkunde zu Berlin. 112.

Tietenberg, T. (2006). Environmental Natural Resource Economics. Boston, Pearson Education. 654.

World Bank (1992 -1996). Statistical Handbook 1996, States of the Former USSR. Washington, The World Bank.

Cited internet sources:

- http://www.weatherbase.com/weather/weather.php3?s=078683&refer: Weather Database. Visit on 15 October 2009.
- http://www.britannica.com/EBchecked/topic/610152/Turkmenistan: Encyclopedia Britannica Online. Last visit on 21 September 2009.
- http://www.ecogeodb.com/ECO_Detail.asp?P=Water%20Resource&CN=Turkmenistan&C=TKM: ECO Geosciences Database. Visit on 30 August 2009.
- http://www.cawater-info.net/amudarya/index_e.htm: Portal of Knowledge for Water and Environmental Issues in Central Asia. Last visit on 1 October 2009.
- http://www.fas.usda.gov/search.asp?sort=date%3AD%3AL%3Ad1&output=xml_no_dtd&ie=UTF8&mode=simple&client=usda&num=10&site=FAS_MAIN&q=turkmenistan: Foreign Agriculture Service. United States Department of Agriculture. Visit 18 October 2009.
- http://www.adb.org/environment/desertification.asp: Asian Development Bank. Visit 24 September 2009.
- http://en.wikipedia.org/wiki/Aral_Sea: Wikipedia Online Encyclopedia. Last visit on 5 October 2009.

Appendix I

INTERVIEW DATA

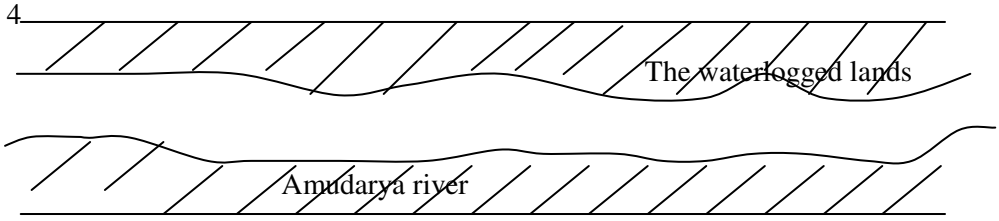
Interviewee # 1

Level: Urban Expert Data: April 2009

Organization: The Ministry of Agriculture of Turkmenistan Location: Ashgabat

1. When there is water availability then everything is well but when water is absent (possibly in 5 years) then there are emptiness (empty patches) on which nothing grows. In such case for animals it is difficult to reach water because the land is waterlogged and animals fail into it.

4



The waterlogged lands

2. The climate varies, air temperature grows (its personal opinion). Animals hardly tolerant such conditions.
3.
    a. Precipitation and water because in the river's upper part (Afghanistan) each state uses waters of the river for the various purposes and consequently the water stocks are decreasing in the middle and lower courses (Nukus). Not every year it is possible to fill reservoirs with water. Number of population increases from year to year therefore water demand grows and agricultural fields increase. This question is now considered at high level. Presidents of 6 countries - Kazakhstan, Tajikistan, Uzbekistan, Afghanistan, Kyrgyzstan and Turkmenistan, try to solve this problem altogether. During the dry periods it catastrophe also influences the nature and protected areas.
    b. From Uzbekistan (Karshinsky area) merge into Amudarya collector-drainage waters which has considerable amount of salts and pesticides and in Tashauzsky area it practically becomes not drinkable. Turkmenistan already does not merge its CDW into Amudarya, but pour into Turkmenkol «Turkmen lake»
4. I do not know, probably it will affect on flora and fauna. The number of animals and plants will increase which have to be entered in the Red book
5. The cotton, wheat, rice and vegetables, melon - all those cultures which grow in Turkmenistan (a potato, gardens, vineyards, etc.).
6. Everything is planted which is beneficial and can be sold in the market. On the state lands according the state order (cotton and wheat).
    a. 1) because conditions are the most favorable (climate); 2) cotton is "white gold" – on economic purpose; 3) and wheat for own consumption – a foodstuff for population. It is the strategic policy of our state.

b. On households people plants at own choice

7. In the market and abroad, and from the leaseholds all yields are delivered only to the State, except a cotton, wheat and rice. For example, a farmer should plant 50 tons of a potato, but he plants 70 tons. He hands over 50 tons and the rest leaves himself.

   a. water charging – on leaseholds the state provides everything with concessionary terms, and on a private plots people must buy everything themselves.

   b. Water within a limited quota is free of charge (10-20 m3/ha), but over quota they have to pay

8. 1) Land and water shortage (0,30 ha for 1 person, but size of farms should be 30 ha). Now the state allocate up to 3 ha for private farmers (leaseholders who well worked).

   2) Soils salinity due to a CDW discharge (CDW are salty with pesticides)

9. Collector-drainage waters discharges (CDW). They are formed on places where water is used excessively, i.e. not rational. If the land is not irrigated regularly, underground waters rise up on land surface together with salts.

10. 1) to apply techniques with minimum water utilization – a drop irrigation.

    2) to apply (to plant) species with smaller water consumption

11) Nature protection workers will answer

12) It is not in our competence

13) certainly excites. The whole area of the country – Dashoguz province suffers from Aral sea influence. Salt from the sea bottom is brought and forms a salt film. First of all it influences population health.

14) The Staff of Interstate Fund for Saving Aral Sea will answer

Interviewee # 2

Level: Urban Expert Data: April 2009

Organization: The National Institute of Desert, Flora and Fauna Location: Ashgabat

1. The condition of environment are under the big influence of human activity (the anthropogenesis factor)
2. During last 20 years it has worsened, because of conducted agriculture, the life of people forces them to use natural resources very intensively. Forests which once were very dense, they have simply disappeared because they have been almost cut down. 3 km were distance from my village to the river, and this territory used to be filled with forests earlier, but now it is visible how forests grew. Nothing remained from forest. I there have grown up.
3. Active agriculture, cultivation of the new lands. Why? Because the population grows, there is no planned development of a riparian zone.
4. Yes, water stocks have significantly decreased.
5. On private plots people can plant fruit and vegetables, but on leaseholds mostly cotton. It is necessary to leave from a monoculture! At the Soviet Union time a crop rotation was very strictly conducted, but now it is absent.
6. According the state order
    a. Other crops are also planted but on private plots. On peasant association's lands due to shortage of money
    b. If it is private land then people have a choice, but on leaseholds there is no choice
7. On a market, market relations. There is no planned development. People buy on a market for market prices.
    a. Water is free of charge, it is allocated by peasant association
8. Quality of soil is unknown. We plant a water-melon on a land which full with urea, herbicides. There is no monitoring system for soil quality. During Soviet Union time through each 500 m specialists took sample for chemical analyses. It is necessary to restore such system at National Institute of Desert, Flora and Fauna or as a whole in Turkmenistan.
9. Not rational use of land and water resources
10. Application of modern methods of agriculture
    a. Agro biological methods
    b. Methods of modeling – which will consider impact factors and where and what have to be planted, i.e. the scientifically-proved approach
    c. Agro melioration method.
    d. Usage of economic-mathematical methods

    Earlier the Agro-industrial Planning Centres planned and conducted such activities. It is necessary to plan agriculture with the scientifically-proved approach.
11. Protection actions are conducted well, it turned toward the improvement. Techniques for the industry are ecological with use of euro standards.

12. There are a lot of problems. First of all is the legislative. It is necessary to improve the national legislation taking into account issues of a modern condition of environment. Example, there is no definition of «greenhouse gases» in the national legislation. It is necessary to bring national legislation to conformity with the international legislation. In this occasion there is even a decree of the President as there was an inquiry from Parliament.
13. I do not understand this problem. About 300 years ago Aral Sea did not exist at whole, and Amudarya flowed into Caspian Sea. If water is not sufficient for people and 600 kg of a dusts are blown away from its bottom every year then it is huge problem.
14. Allocation more water into the Aral sea

Interviewee # 3

Level: Urban Expert Data: April 2009

Organization: The Ministry of Nature Protection of Turkmenistan Location: Ashgabat

1. The condition consists of forests and agriculture. There where woods, there reserves are created with the purpose to preserve and protect riparian ecosystem (bushes and Tugai vegetation). The agriculture is conducted for the population. Jargozel is beautiful places which have remained on Murghab where sands at the right coast and woods at the left coast are beautifully combined.
2. Change of climatic conditions. Basically depends on water resources since occurs droughts or floodings. When there is a lot of water, the nature is good. In the Amudarya Reserve the condition has been improved by employees of Amudarya Reserve. Outside of the protected area the agriculture is conducted which also depends on water resources.
3. Soils salinity. 1 ha of the land was taken from Amudarya Nature Reserve for agriculture purpose. Thus, it led to an intervention in Shorkolwas where the migratory birds inhabit. Variation of climatic conditions can have effect on environment and bring deterioration such as water reduction.
4. The climate is dry and it negatively influences environment
5. The cotton, grain crops, rice. Sometimes people plant greens and vegetables
6. Everything is decided under the state plan. Now basically rice because it solves salinity problems. Also people plant a poplar (*Populus*), oleaster (*Elaeagnus*) along the roads. For a crop rotation after cotton Lucerne is planted (5 years a cotton then Lucerne).
    a. To provide a gin factory and cotton related plants with the raw materials cotton is planted. Cotton is planted mostly for economic targets - for export.
    b. If you work in peasant association than you have to follow its plan. If you are private farmer you lease the land and plant what you want
7. Hand over in peasant association, but what you have grown up on your own decision you can sell in a market (tomatoes, water-melons)
    a. Yes pay for technics, seeds and fertilizers. Costs for services are taken from the received benefit.
8. Little water resources
9. Impacts are
    a. Not rational use of water resources, which leads to washout and small lakes, also reduces to formation of channels.
    b. Used land are remained without supervision, they are overgrown by reeds and woods are appear
    c. Many lands are affected by salinity because of not rational water utilization
10. Now Collector- Drainage System are under the construction, reeds are cutted off, the old lands are cleared, washed out and used again

11. There are already many improvements – the legislative base has improved, old lacks are eliminated, a state policy and country governing body coordination
12. Problems are following: 1) basically problems are connected with shortage of human capacity due to the large size of territory. Only 10 inspectors are working in each provice and 2025 in reserve. 2) also a technical lack, the technician of the control on a long distance – portable radio sets, etc. 3) fires - for struggle against fires a Nature Protection Society and Boundary Service assist with devices of night vision during fires season, but is not enough of it.
13. Excites certainly. Dust storms reach and bring many salts and a dust to the many regions. They negatively influence people health and environment. Aral sea shrinks but Caspian sea on the contrary increases. There is some interrelation, a nature riddle.
14. To work well is necessary. To conduct forest plantation, to plant trees and shrubs. To use a drop irrigation in agriculture.

Interviewee # 4

Level: Urban Expert Data: April 2009

Organization: The Ministry of Nature Protection of Turkmenistan Location: Ashgabat

1. Condition of environment is good. But recent due to water scarcity the situation worsens
2. Due to less water resources the climatic conditions worsen, this in turn influences the nature. Consequences of Aral Sea are as obvious case to you.
3. Environmental contamination. These are a few factories and factories which enit emissions. For example, the Phosphoric factory in Turkmenabat city influences environment. Usage of fertilizers in agriculture, soils salinity, etc.
4. Do not know
5. Cotton and wheat – 90 %. Besides trees, vegetables, lucerne, rice. For performance of the State plan the crop rotation does not implemented!
6. According to the state plan.
    a. To provide the textile industry with raw materials and granting of workplaces to the local population
    b. Why cotton? Because peasant associations do not manage to follow the state plan and to hand over the planned cotton yield
    c. From this year under the President's decree the crop rotation is introduced. On March, 15th National Council was held on which basically agriculture issues have been considered. It was decided to distribute the agricultural crops planting scheme according to land, water and climate condition, i.e., Dashoguz province – to plant less cotton, but more rice and wheat, Akhal province –to plant more cotton, Lebap province – as before to plant cotton, rice and wheat and Balkan province to plant mostly fodder crops.

    Till 2004 the state allocated 1 ha for own property (ownership) from Land fund of collective farm. The land was allocated to 1 person working in a family.
7.
    a. Wheat – joint-stock company "Gallaonumleri",
    b. Cotton – the Association "Turkmenpagta" is bought through a Commodity-Raw Stock Exchange with 50 % discount
    c. The technician – «Obahyzmat»,
    d. Fertilizers – «Dokunchimiya».

The Economy Development Fund allocates financing to these organisations. Agriculture combines collect and carry a crop to the harvest delivery point, there the harvested yield is measured and calculates the benefit.

For water and other stuffs such service and raw materials farmers pay only 50 %.

8. 1) low quality of seeds. For example, seeds of 1st year are used next year for seeding. Seeds of 3rd year are delivered on manufacture (flour-grinding factory). Now seeds are imported from Krasnoyarsk and Stavropol.

2) Water scarcity

3) Fertilizer shortage

4) The lack and exhaustion of technics (agriculture vehicles)

5) The absence of crop rotation (or very poor)

9) Impacts are

1) It is necessary to get rid of primeval vegetation because land processing for agriculture of that is required

2) Fertilizers usage – herbicides (gliphos, raundat for weed destruction) are used after harvesting or before seeding. Herbicides – against worms which drink moisture (milk) from wheat stalk. A scoop in is formed in cotton which destroys a cotton box.

It is difficult to find the real Land Owner – the person who well knows and uses land.

10) How to improve:

a. To conduct a crop rotation
b. Mechanisation – to improve quality of services
c. Timely fertilizer of soils
d. Water consumption - to clear CDW networks and anew dig up

11) Does not know, but ecologists take over environment condition

12) To improve technical maintenance – number of poachers are increasing and consequently we feel shortage of vehicles and the qualified experts

13) Certainly excites

14) The Heat station in Tajikistan is under construction can negatively influence environment, therefore it is necessary that the international experts have been involved during the construction process. The president of Turkmenistan has told «Use water rationally and in this case problems of Aral sea could be solved»

Interviewee # 5

Level: Local Expert | Data: March 2009

Organization: Amudarya Nature Reserve | Location: Lebap velayat

1. When the agriculture is developed, forests are degraded. Since 80th years to increase area under cotton there was a decree to cut down wood from 2 parties of the river of Amu Darya and to capture for cotton plantation. In 1982 the Amudarya Nature Reserve was established for the purpose of preservation tugai forests and tugai deer inhabiting in these places.
2. The protected area has very much changed to the best. The Reserve exists for 27 years. Before here Tugai forests were very degraded, the lower grassy cover was not, every year woods were set fire that the grass for cattle grew. We did not operate strongly, we did all slowly, worked with the local population that they have understood that the reserve is necessary. 405 deer inhabited, and now only 120 remains. The reserve benefits us, instead of harm and some help us.

   Outside of protected area – Gok-Gushak (Green Belt) monitors, but they do not have salaries and staff has been reduced. Therefore security work has worsened.

   The area of Tugai forests were accounted 30 000 hectares on the Amudarya valley (Gladyshev), and now there are 6000 hectares in a protected area.
3. Water scarcity. The reason is climate change across the Central Asia. The moisture is not enough from year to year, and the water consumption is increased by neighboring countries such as Uzbekistan and Afghanistan.

   In Tajikistan platinum for hydroelectric power station is built. At a meeting of Presidents of the countries it has been decided to make the international expertise on purpose to estimate damage as to environment and neighboring countries. For 2 years we may remain without water. If flooding take place that Tugai forests revive and we are glad.

- overgrazing outside of protected area
- fires regularly outside of PA, in 2005 fires burned 80 ha in the territory of the reserve
- agriculture not coducted inside of PA, but outside. In 199___ some part of Nature reserve was withdrawn for agriculture
- hunting happens but not often in PAs,
- climate change – in 2008 there were a few precipitation and Amudarya river had fewer water
- pollution due to vehicles

4. Yes, it influences.
5. Cotton and wheat. For our own needs we plant wheat, and for economic targets a cotton. There is watermelon, fruit, grapes, grain, rice, a string bean, vegetable marrows and other new cultures.
6. Daykhans (farmers) have its own property of 0,26 ha where they plant that is necessary for their family. On the plots leased they plant under the contract according the government plans

a. The state order – a cotton worth its weight in gold, to provide ginning and cotton-spinning factories, oil factories – all for cotton processing which makes profit for the country.

b. 0.16 or 0.25 ha – allocated to a family in villages, 0.04 or 0.08 ha in a city as a private plot

c. In the private plots one may plant on its own and in state under the contract, but from a cotton and wheat receive benefit

7. Where: on a market

   Whence: on a market we buy seeds, fertilizers such as super phosphate from the state (Turkmendokun) is paid, water – comes by channels (aryk). Last year water was brought on collector-drainage system (CDS) because of water shortage (2008). For water it is paid scanty cost to help a private sector.

   It is paid a little, i.e. cost is low. People watered many times the garden and never paid. It is said that water is free of charge.

8. Problems: the techniques were earlier a problem, but now not. Excavators well work, and clear CDS.

9. Earlier there was a cutting down of woods and cultivation of the new lands. Now there are no woods and there are no problems.

10. Actions:

    a. To conduct intensively manufacture

    b. To improve the soil fecundity

    c. To restore Tugai forests behind a dam, they protect from water and wind erosion, fix soil and protect from flooding

11. On the proper level. For 20 years has changed. People did not trust that the Reserve here will function and gradually people have started to understand about importance to protect and keep the nature

12. Insufficient financing and logistic support, we do not have helicopters to take over Reserve

13. Aral sea problem certainly excites me, soil salinity and water scarcity is the huge problem in nearby regions, in Turkmenistan it is Dashoguv province

14. To allocate more water to Aral sea

Interviewee # 6

Level: Local Expert | Data: March 2009

Organization: Amudarya Nature Reserve | Location: Lebap velayat

1. In reserve the state of environment is good, but out of a protected area the situation is much worse.
2. The area of Tugai forests was reduced, pressure on environment has increased. The area of agricultural fields has enlarged, their condition become worse.
3. The agriculture threatens, because due to agriculture the forestry is reduced. The priority places in the economy take bread and cotton.
4. Yes, it influences a little.
5. Farmers grow up basically a cotton and wheat, a little rice, grain and vegetables
6. The contract with farmers and peasant association is being concluded to rent a plot of land
    a. Plant what is priority, i.e. that which has a demand and that is necessary for the State
    b. On the leasehold there is no choice and on private plots people plants what they want
7. For water people do not pay, but pay for use of pumps, fertilizers also pay for seeds, techniques (to plough and harvesting). For harvesting cotton leaseholders pay to collectors. The reaped yield is delivered to the State.
8. Shortage of water, fertilizers, soil salinity and weather conditions (climate change)
9. "Weed and pest-killer chemicals" – pesticides, herbicides, a deflation (cotton leaves) all it influences environment. Surplus of fertilizers passes through soil and water. Hydro constructions – channels and collectors (for watering and drainage waters) and dams too influence environment
10. Following actions:
    a. Reduction of the agriculture areas, instead of expansion.
    b. Increase soil fecundity (introduction of soil rotation).
    c. Observance and maintenance of water protection zone – a wood strip where nothing should be done – cattle grazing, forest clear cutting and agriculture. Such strip should pass along the river bed with a width 2 km.
11. Differently. Some issues are sorted out better, others are worse.
12. The main difficulty is that "Nature protection" does not take the top place among the government issues, it not a priority problem. Besides lack of specialist and an objective estimation of a real situation
13. Yes this problem excites me.
14. It is not possible to solve this problem in that condition

Interviewee # 7

Level: Local Expert | Data: March 2009

Organization: Amudarya Nature Reserve | Location: Lebap velayat

1. Winds amplify in the spring, in the summer – strong winds, humidity – low, in the summer hot. In settlements there are no woods, they have remained there where there are no people, and there are no settlements
2. the weather became hotter, woods became less. People began to open more and more the new land for agricultural fields, and use less pesticides and herbicides
3. All which is connected with human activity – anthropogenic influence
4. Evaporation is more than precipitation, it aggravates an ecological situation.
5. I have a private plot (household plot) – 0,16 ha, there I plant vegetables and greens, and got 1 ha as leasehold, there I plant a cotton.
6. Solves peasant association according to the State plan
   a. Climatic conditions allow to plant cotton and due to an economic target
   b. For 3 years I have planted wheat and now started to plant cotton – for the purpose of a crop rotation
   c. On a State Planning Committee

   Comparing an economic gain of 1 ha wheat and 1 ha cotton more beneficiary is to plant cotton! However, expenses for cotton planting is a lot also – water, fertilizer, techniques, harvesting costs etc.
7.
   a. Where: to state organization “Turkmengallaonumleri” (Turkmen Grain Board) which provide with a car and take away all yield
   b. Whence: we received everything from the state – water from “Suwhojalyk” (Water Users Ass) self flowing on channels, fertilizers we buy in shop of "Turkmendokunhimiya" (Turkmen Fertilize Supply)
   c. For water and the land we do not pay
8. There are no problems
9. Excessive water utilization leads to problems such as soil salinity, high level of watertable
10. To use less pesticides and herbicides (at rates); to use more mineral fertilizers (ammonia, potassium, silicate, sulphate); to use a drop irrigation; to use organic fertilizer – manure.
11. It became better. Earlier an agriculture helicopters were throwing down defoliants on settlements, and now such actions are not conducted.
12. Basically it is agriculture. Animals sit down on agricultural fields and people kill them, thus, number of some species decreases
13. Do not know
14. Do not know

Interviewee # 8

Level: Local Expert Data: March 2009

Organization: Amudarya Nature Reserve Location: Lebap velayat

1. Environment in a normal condition, everything is here – soil and water, a good climate both for nature protection and for agriculture
2. Every year is different and has different influences both on nature protection and agriculture. Last year there were few rains and it impacted the nature and agriculture. Rains feed the river one year less, another year more. Climatic situations are different every year.
3. The nature itself does not threaten. Anthropogenic factor influences the nature – land cultivation which is also necessary for humanity, the population increase who needs to be fed and dressed. Nature preservation is very important! Therefore we are here not to allow people to destroy all natural resources but to use them rationally and to observe legislation.
4. Climate has certainly changed. It influences environment. When climatic conditions are good then it is good for the nature and if climate is sharp then it negatively influences the nature.
5. Cotton and wheat (grain). Besides water melon, gardens, grapes, vegetables, a potato, fodder (a Lucerne and corn), rice and a mulberry.
6. On the state land (collective-farm) plant according a State Planning Committee, how many cotton and wheat should be a planted is given under the state plan.
    a. Soil and climatic conditions allow to grow up heat-loving plants, the sum of temperatures allows, in other regions not possible, and from economical point of view for the state.
    b. There is own choice only on private plots – households (mellek). In peasant associations according to the President's decree 1-2, 5-10 ha are allocated where people can plant everything they want.
7. Where/where: on a market, bring on the market place

Whence: seeds from shop, from Lebap province, fertilizers also from shop, manure from a stall of cattle, water – from aryks (irrigation ditch). For private needs water is free of charge, and farmers take water from aryks with the minimum payment. Seeds and fertilizers are given out by the state with 50 % discount.

8. The agriculture depends on climatic conditions – waters, the climate (wind, precipitation and temperature) when there is good water provision and a climate is favorable then everything is good. If we have planted and next day it is raining then it is bad.
9. Waste on CDS – the rests of pesticides are fallen, fungicide (against illnesses), herbicides (against weeds) – pollute water and soil.
10. To use biological methods – bio humus, to liquidate wreckers, to use gabrobrakon – against caterpillars of butterflies taking off in the field and eating cotton bolls, for protection of agricultural products. Trihogramma – against eggs of butterflies, etc.
11. Nature protection is conducted well, people already competent, experts work, quality of work improves every year.

12. There are not sufficient logistics and transport (boats, equipments for the control) support. Unfortunately poachers are equipped better than we
13. Certainly excites. It influences the nature both on region and global levels
14. For all problems there is an solution. There are not unsolved problems. The number of population grows and consequently it is necessary to allocate water and financial support more.

Interviewees # 9, 10, 11

Level: Local Expert Data: March 2009

Organization: Nature Protection Department of Lebap province Location: Lebap velayat

1. The forests grow on river bank, the river is washed away. We plant reed (its height reaches during a year up to 25 meters) for river bank strengthening from washout. In whole the condition is normal.
2. Many have changed toward good side
3. The change of the river bed. In 1969 and 2008 the river has frozen and it was exploded to prevent flood. Water is allocated at rates fixed in the Agreement between neighboring countries.
4. Yes climate change influences. If there is a little waters the fish resource and the vegetation will decrease, an soil erosion will take more place. The more water the more land we can irrigate.
5. In a forest belt (a forestry – Gok-Gushak), and in a protected area the agriculture is not conducted, sanitary-protective zone is being observed which reaches by 100 m. River bank strengthening actions are being implemented by «Amudaryakenarbirleshik» (Amudarya river association). They dig out the basic bed of the river, not changing its course. Our department (DNP) also monitors and supervises this process.

Basically people plant cotton and wheat. This year it is planed to plant more vegetables.

6. Everything is being done according to the state plan.
    a. On the private put melon cultures, rice, cabbage, etc., and
    b. on the leasehold plot according to the State Plan.
7. Where: on the market; whence- does not know
    a. Leaseholders pay for water within limited quota (low price)
8. Flooding. Usually it happen when underground waters rise, CDS involve water. If it happens along Amudarya because of washout it is considered as natural calamity.
9. Change of the river course (bed)
10. Do not know
11. Normally, has improved. The newest technology is being used; protection is regularly conducted by inspectors of department. «Suwhojalyk edara» (water management service) conducts monitoring and carries out the chemical analysis of water from Kerki till Charshangy.
12. We have techniques, in the 1990th we did not have any, and consequently could not dig a the river bed. Therefore there were many problems
13. Certainly this problem excites, the climate can change and lead to high dryness (droughts)
14. Seraks lake in Dushanbe, if Tajikistan constructs the platinum (dam)

Interviewees # 12, 13

Level: Local Expert Data: March 2009

Organization: Nature Protection Department of Lebap province Location: Lebap velayat

1. Inundated forests on both side and for the necessary purposes (cattle breeding) a forestry is conducted. Prevailing species is turanga *(Populus*) and grebenshik *(Tamarix*), the licorice (Glycyrrhiza) and reed *(Phragmites*). The main function of the forest is water regulation. The cattle breeding, cultivation of various species, cotton and wheat is conducted also. On open sites the mulberry, as a water regulating tree is grown up for economic targets.
2. Not substantially. Forests were clear-cut. In 1985-1990th these open land were used for agriculture purpose.
3. There are no considerable threats. The main threat is forest clear-cutting, but it is sometimes necessary if woods are already old in order to avoid fire.
4. With the lapse of time there can be climate warming which will negatively affect environment.
5. Cotton, wheat, rice (10 000 hectares). For cattle people grown up fodder such as barley, Lucerne. More over the planting areas of fruit has increased, a mulberry – 482 thousand pieces. According to the decree of the President it is also necessary to increase a plating of water melons. The main task of the agriculture now is to provide population with a sufficient foodstuff!
6. According to the contract, farmers plant what is stipulated in the contracts made with «Gallaonumleri» (Grain production association) and «Turkmenpagta» (Turkmen cotton association).

Having 1st yield (in May) leaseholders can plant what they want (certain species). During the year people harvest wheat twice and cotton once.

Planting regime of cotton is in April 5-25th – planting, August 15th - November 1st – harvesting.

Planting regime of wheat: the beginning of September and the end of October – planting, May-June – harvesting.

Intermediate planting is rice.

Rice: the end of May – planting, in October – harvesting

7. Everything people receive from «Gallaonumleri» and sell to them as well
    a. For water people pay not much, the cost is insignificant
8. Lack of scientific approach in agriculture. There are not enough seed-growing institutes and experimental stations in the country. Water utilization is not rational, techniques misuse; plantings are implemented not according to climatic conditions.
9. There are no threats.
10. tree plantings, use of the scientific approach
11. Better than earlier.
12. There are no problems
13. Yes excites, it would be desirable to keep for the future
14. Economically use water from both parties of the Amudarya river

Interviewees # 14

Level: Local Expert Data: March 2009

Organization: Nature Protection Department of Lebap province Location: Lebap velayat

1. All forests have a protective function (group 1), the river flows among Tugai forest tracts. 5 points (in some cases by 0 points) depending on the river bed and economic activities of the local population. Tugai forest tract is considered valuable, it can well restored itself. It should be left simply alone and even after disasters, simply not to touch, and then it will be restored. However it is necessary to perform do fire-prevention actions. The irrigated zone locates within a valley of Amu Darya river.
2. There is a contrast. The condition has improved in difficultly reached places, but accessible places has worsened or at the same level (10 years). The protected areas are not accessible and they are well protected. So conditions there have improved. In Turkmenistan protected areas are covered only 4 % of the country, and we are sure that it is possible to improve situation if the territory of PAs would reach by 10 %.
3. Fires, due to the high density of Tugai vegetation. The reed and Tugai vegetation have crusts and they protect and fix soil. If there are fires then root system will decay and water washes away soil along the river. Fires occur not often, but periodically.
4. The climate influences. Water depends on glaciers, and vegetation from water. During the winter there is less water than during summer.
5. Wheat as a food provision, grain – 1-2 %, cotton, water-melon, vegetable growing, gardening, wine growing. The cattle breeding is conducted in a cultural zone and in a sandy zone (small cattle and cattle – outrun pastures).
6. there are 3 land users:
    i. The land of collective farms and state farms
    ii. The land of with forestry and reserved purpose
    iii. The lands of the enterprises and organizations

    The rest of lands belong to the State Land Reserve. Within the households the cultures planting schemes are existed. The state allocates the land, water and gives a task to farmers what to plant. Leaseholders plant according to the task suitable culture in the appropriate land. Land rotation, plough, washing i.e. all melioration actions is being conducted.

    a) For the population - gardening and melon growing

    b) For export – a cotton

    Collectively decides how many fertilizers, seeds, waters are necessary etc. and altogether decides what and where should be planted.
7. Seeds come from the last year's yield, water is provided by the Ministry of Water Management (its division). For instance, the farmer says that he needs to grow up 20 ha of wheat, then he concludes the contract or the agreement with Turkmenobahyzmat (Turkmen peasant service), Turkmendokunhimiya (Turkmen fertilize chemical), etc. and they provide leaseholders with water, fertilize etc.

   a. Yes people pay for water. There is a limit for water, as for amount of provided fertilizers it depends on crop. Water is not allocated over the limit, and each soil has the water consumption norm (quota). 5 thousand ha under wheat, 8 thousand ha under cotton.

8. Do not know.
9. Irrational use of water, destruction of Tugai forests, fires, secondary soil salinity, water pollution.
10. To forbid an enlarging the agriculture, to enter a drop irrigation, biological protection of agricultural vegetation, to put the Tugai forests under protection. It is possible to combine but protection is necessary. In Turkmenistan the duties of the Forestry activity are:
    a. Cultivation of wood shrub species
    b. Cultivation of economic estimated activity
    c. Security activity.
11. In 1989 the Ministry of Nature Protection has been established, before there was no protection activity.
12. The lack of specialists.
13. This problem concerns me. Amudarya and Syrdarya do not flow into the Aral sea any more. Thus we have following problems: 1) accumulation of salt from a sea bottom, then it dries out and rises up. Northeast winds lift this dust and salt and brings them and pollutes our environment – formation of the secondary salinity; 2) If such situation takes more time then the climate and population health will worsen.
14. To rescue Aral Sea:
    a. to consider this question more economically: rational water utilization, not only collective farms and state farms but everyone in the kitchen garden should think about this.
    b. to conduct propaganda propagation what is necessary to do, to influence people consciousness.
    c. to use water resources more economically. To plant more water economic cultures and stands for water saving strip, to breed camels instead of bulls

Interviewees # 15, 16, 17

Level: Local People (representative from local authority, Imam and Aksakal) Data: March 2009

Peasant association: Kabakly Location: Lebap velayat

1. Everything is good. Staff of Nature Reserve well work. Flora and fauna in a good condition and a climate is nice.
2. Yes has changed toward good direction. There are forests grow along Amudarya River and a lot of living creatures. All this gives a cool condition.
3. Influences nothing. People conduct water regulation activities as dam construction.
4. Yes the climate influences, it is difficult to work when the climate is not good. Every year a climate is different, this year it is good, temperature about 25 oC, but last year it was very cold, in the winter – 16 oC. It has affected environment, the river has frozen. Nowadays there are less patients in hospital that is also a sign of nice ecological situation in our region.
5. We grow up cotton and wheat, and also a mulberry and vegetables. Our village (Kabakly peasant association) has handed over to the state 808 ha of wheat and 810 ha of cotton.
6. On leaseholds (1-2, 3-4 ha) farmer plant in the frame of the contract which is made for a year. In the contract everything is stipulated, what to seed etc.
    a. Cotton is planted because it favourably for our peasant association
    b. On private households people plant what they want – 0,16 ha. We buy nothing on a market, we grow up everything we need.
7.
    a. Where: some part we sell to the State. The yield from private households we use for home needs and what is remained we sell on a market.
    b. Whence: water we pump from Amudarya river, 4-5 pumps, it reaches to Uchkersen. Water is free of charge (3 % is charged in the end of a year from the total received sum); fertilizer we obtain from «Turkmendokunchimiya», seeds from «Turkmenpagta» (they are already processed) with 50 % discount and the technical service from «Obahyzmat».
        - Everything is foreseen in the contract what to plant, how to process land, where from to take water, about working conditions and payments.
        - During the year the list with conducted activities are compiled and in the end of a year expenses and incomes are described.
8. Soils salinity, but cleaning actions (zeykesh) have already begun
9. Does not bring any harm, it is necessary to increase farmlands because the population size increases
10. To improve a land fecundity i.e. to conduct the 2nd sowing (ekeranchilyk)

11. From the established date of Amudarya Nature Reserve the condition has improved. Forestry Service conducts the control and protection activities of forest – cutting down of woods is forbidden, plants along roads are planted, cattle grazing are allowed in desert during the whole year.
12. There are no problems, there are no infringements, people observe all rules and orders. If there are any infringements than they are fined. The population itself is interested in nature protection.
13. Yes we know about this problem. When the wind rises it brings a dust and salty rains – these all negatively influences environment and on people health.
14. Some do not know about the reasons (1 person does not know and 2 know). The water consumption grow due to enlargement of population size and therefore it is necessary to use water economically. “Suwgozegchilik” (Water monitoring service) and Mirap service regularly conduct the control over water use. There are 6 hydroknots in Gazanchak, works only one hydroturbine.

- 3162 persons – in Kabakly Council (Geneshlik)
- 4 settlements (villages) – Kabakly, Kabaklyoba, Uchkersen, Halkabad
- 583 farmers in peasant association

We have visited village Kabakly

Interviewees # 18

Level: Local People (farmer) Data: March 2009

Peasant association: Kabakly Location: Lebap velayat

1. We have a good environment. The nature is nice.
2. It has changed toward good direction. I was born here in 1964.
3. There is no harm to the nature.
4. Last year the weather was cold, a lot of cattle has died out. We have stove heating, in each house independent heating. Grapes have frozen. We had to cut it down completely, only some young stands have remained.
5. I have a private plot 0,16 ha, leaserhold 2 ha. I harvested 35 centners of wheat. I plant wheat according to the contract with Daykhan birleshik (peasant association) which has the contract with «Turkmengalla». And on the private plot (household) I plant greens, garlic, a tomato, etc.
6. On the leaseholds I plant only according the State order – wheat. As soon as I harvested wheat I have planted greens on my own accord.
7.
    a. Where: Wheat has handed over to the State – peasant association (Turkmengalla), and greens from a private plot I have sold on a market.
        i. 270 DTM – for 1 ton of wheat,
        ii. 5 200 000 manat = 1040 DTM – 1 ton of a cotton
    b. Whence: water, seeds, fertilizer and technical vehicles are provided by peasant association. Everything is allocated to the credit. After harvesting 50 % of all expenses are paid back.
8. There are no difficulties
9. Do not know
10. Do not know
11. The nature is well protected
12. There are no problems if the economy is conducted, there are single instances
13. he is a little familiar with this problem
14. It is important for us, for health and our children. It is not necessary to break trees, to kill birds, it is necessary to plant trees!

Interviewees # 19

Level: Local People (farmer) Data: March 2009

Peasant association: Turkmenabad Location: Lebap velayat

1. Environment is in good condition.
2. Many trees were cut down before, but now many trees such as pines are planted. The climate worsens. The last year the weather were colds but this year many rains.
3. Anthropogenic influence – cutting down of woods, hunting, contamination etc. The last year due to a cold weather a lot of cattle died out. The intensive agriculture is conducted and the new lands are cultivated.
4. Yes influences. Last year there were strong colds. Buds, early for this time of year (not season) have already blossomed. I think there is a balance infringement in the nature.
5. We grow up greens and vegetables in our household.
6. Everything is planted in the frame of the contract. 50 % transfer to the population, and 50 % to the state. As for cotton, all yield shall be sold to the state. Farmers lease the land and conclude the contract with collective farm (peasant association). A peasant association has a plan which is obtained from the state.
    a. Climate favorable for cotton. The cotton is our riches, our raw materials to provide textile industry. From cotton we produce oil, a peel which we use for as fodder, make a laundry soap, etc. and its branches are used as wood.
    b. wheat, rice, vegetables and greens
    c. On the leaseholds we plant according the decision of a peasant association
7. Where: on a market, if it is wheat then it shall be delivered to Gallaonumleri association and if it is cotton then to Turkmenpagta association. These associations provide with raw materials (seeds).

The contract with peasant association is conducted and then «Gallaonumleri» allocates grain as seed, «Turkmendokun» provides with fertilizers, and «Suwhojalyk» service with water. At yield reception all expenses and incomes are calculated. Expenses for provided services and raw materials deduct from the obtained income and in the end the net benefit in the monetary value is assigned to Daykhan Bank.

In the contract everything is stipulated - how many should be grown up (30-40 centner). The harvested crop is delivered to peasant association. When farmers plant cotton they receive back the peel (seeds) which later can be delivered to Oil factory and make oil. The processed peels are used as fodder for cattle.

Yes probably, people pay for technics, seeds and fertilizers.

8. I do not know
9. While cultivating the new land many woods are cut down, but while conducting agriculture there is not any harm. On the contrary the lands are cleared, salinity disappears.
10. We have a lot of the deserted territory, it would be nice to cultivate these lands as well

11. Yes, the nature protetction system has improved. For the last years many Reserves such as Amudarya, Repetek and Kugitang have been established etc.
12. Do not know
13. Never pay attention
14. For the future generation. It is necessary to conduct conversations with the population, interview on radio and TV, awareness raising about nature protection and ecological problems.

Interviewees # 20

Level: Local People (farmer) Data: March 2009

Peasant association: Turkmenabad Location: Lebap velayat

1. At present an environment condition including flora and fauna along the Amu Darya river are in a satisfactory condition.
2. It is necessary to tell that plants and animals for last 20 years were reduced, fewer fish in Amudarya river than before.
3. In my opinion the there are not particular threats except for climatic differences which influence environment. However, the economic crisis increases illegal fishing in the river and a poaching which in turn reduces number of animal etc.
4. Yes the climate influences. So for example, plentiful precipitation or a drought, frosts – all these climatic chages influence environment. Last years sharp frosts and colds have led to the frosts of river and soils. At that time many cattle died out and vineyards have frozen.
5. In leasehold I grow up **wheat** and in household vegetables for my family needs.
6. We co-operate with local agriculturists and they decide what exactly (kind of crop) and where necessary to plant. I think they follow the government decision. We conclude the contract with peasant association.
    a. I do not grow up wheat
    b. I sow wheat according to the advice of the agriculturist
7. Where: all harvest I hand over to peasant association – to the state, whence: seeds, fertilizer and water we take from the state organisations.
    a. Yes we pay, after harvesting we pay for the provided services to the state, i.e. they deduct from the received profit for wheat
8. there are no any particular difficulties in agriculture. But this year there was a problem so called "korenglin". After seeding process when the soil receives excessive quantity of moisture seeds perish. This year we have plentiful rains which have affected it.
9. Probably not rational use of water which leads to soils salinity.
10. Realisation of a drop irrigation it would be possible to reduce water use and by that to save river water
11. Economic crisis influences all spheres, similarly influences and nature protection
12. Shortage of highly skilled specialists in reserves and Gok gushak (Green Belt organization)
13. Yes I have heard anout Aral sea.
14. Maybe to allocate more waters in Aral sea

Interviewees # 21

Level: Local People (farmer) Data: March 2009

Peasant association: Turkmenabad Location: Lebap velayat

1. All life in this region depends on our river, and human life, its economic activities and a life of animals and plants too. It seems to me that Amudarya river became even dirtier than before and has fewer waters.
2. I think that has changed, toward the worst direction.
3. The people use more natural resources because the population size grows up.
4. Yes definitely, will be fewer yields.
5. I plant **wheat.**
6. In my leasehold I plant wheat and I hand over it to our peasant association according to the state plan.
    a. I do not know but we plant wheat. We must follow everything what is said by our peasant association.
    b. In my own plot (household) I grow up everything what we need, and in the state plot (leasehold) everything what wants our state usually wheat and cotton.
7. Where: wheat I hand over to our Turkmenabat peasant association; whence: everything is provided by the state – tractors, fertilizers and seeds. For all we pay to the state on 50 % discount.
8. Problems basically are connected with the land – soils salinity and water scarcity. And also delayed service of the state organizations – fertilizer and technics are provided not in time. And the climate sometimes also negatively influences.
9. Introduction of fertilizers (soil pollution) and use of water of Amu Darya river (soil salinity)

10 – 14 - do not know

Interviewees # 22

Level: Local People (farmer) Data: March 2009

Peasant association: Turkmenabad Location: Lebap velayat

1. The condition of the nature is quite well – everything is for human life. Soil, water, a climate.
2. I do not think that something changed for last 20 years.
3. Water shortage for irrigation. The amount of irrigated lands is increased from year to year because the Government enlarges the Agriculture plant.
4. Probably days with droughts will be more often, so in this case we probably will switch to another crops and plant something different.
5. Along Amudarya farmers plant everything - cotton and grain, vegetables and fruit. On the leaserhold I plant cotton (2 ha).
6. Under the decision of agriculturists of peasant association.
    a. Because we have the most favorable climatic conditions for planting cotton and to provide cotton gin factory
    b. We should implement the plan and since I have leasehold, I am planting according the contract made with our peasant association. After harvesting cotton I plant on my own – potates and vegetables.
7. Where: cotton is handed over to the state, but potates and vegetable I sell on market and part of it for our own needs
    a. Whence: from the state organizations. I pay in the end when the yield is harvested the bookkeeper calculates our costs and benefit
8. Shortage of technics, water and fertilizers. A climate too, for example this year we have sowed already 2 times. However there were plentiful rains that's why our 1st crops were lost
9. the quality of land became worst and therefore we wash it out and conduct meliorative actions and water is not enough
10. Rational use of water and land resources
11. Protection is conducted well. The reserve also well works
12. Do not know
13. No
14. Do not know

Interviewees # 23

Level: Local People (farmer) Data: March 2009

Peasant association: Turkmenabad Location: Ashgabat

1. We have very beautiful nature. Many forests and many animals along Amudarya river. Of course before there were much more forests but due to agriculture it was needed to cut them down in order to cultivate these lands and plant cotton.
2. The weather become more hotter and dry moreover there is less water in Amudarya
3. Maybe emissions from the industrial factories and different vehicle. During the last 10 years so many new plants were built up. So they may influence our nature.
4. Yes influences, if we have less precipitation then the amount of the yield will be less as well.
5. Cotton (3 hectares) and wheat (1 hectare). The both plots located near so I can manage both.
6. According to the state plan
    a. Under the state decision
    b. If you lease the land it is necessary to execute the plan of a peasant association. But in the private plots we plant potato, garlic, onion and tomatoes and hold also hens and cattle.
7. Cotton I hand over in cotton processing factory and wheat to the local representative of association "Turkmenpagta"
8. We do not have enough water, fertilizer and technics or they are provided not in time. Due to these reasons our yield is poor.
9. pest-killer chemicals which we use in the field can negatively influence environment but without them it is impossible to conduct agriculture
10. To improve soils fecundity, to conduct a crop rotation and to use water rationally
11. Normal
12. Do not know
13. Do not know
14. To save our environment in clean condition for our generations and plant as many as possible the green plants and trees

Interviewees # 24

Level: Local People (farmer) Data: March 2009

Peasant association: Turkmenabad Location: Lebap velayat

1. Everything which is surrounding us-nature, river, and fields are our treasure and we love it as it is.

2. I think that climatic conditions have changed.

3. I think that it is connected with increasing of number of motor vehicles and activity of industrial factories. The main reason is growth of the population size and connected with this a large consumption a foodstuff and water.

4. Maybe air can become more contaminated and consequently affect to people health.

5. before people have planted many cotton, but during the last 5 years they began to plant more wheat and rice. During the last speech, our President told that it is necessary to provide the population with a foodstuff and to increase the areas under vegetable and garden cultures. Therefore I think soon here new reforms in agriculture will begin.

6. The state solves for us, the President more precisely. What will tell that we plant.

   a. Cotton is planted because it is necessary to provide factories with raw materials i.e. for our country's economy

   b. Other kinds of crops have started to plant too – basically rice, different kind of beans. However the most beneficial for farmers is to plant cotton.

I have planted cotton on 3 ha plot and have received 12 tons yield. Total net profit I have received 36 million manat. Since this year I have leased 1 ha land more to plant wheat. I have not harvested it yet.

7. Where: we hand over to peasant association, whence: we receive from the different organisations, we conclude the contract with them and they allocate according to the contract

8. There are a lot of difficulties:

- There are no good lands – many flooded or salted;
- The serving organisations such as "Turkmenobahyzmat", "Turkmenpagta", "Turkmengallaonumleri", and "Turkmendokunchimiya" implement their duties not in time;
- not enough agriculture technics for conduction a land ploughing, land and furrow alignment, seeding and land reclamation and other types of service;
- not enough fertilizers – give nitrogen and phosphorus a little. In shops and market fertilize cost very high;
- not enough water - pumps are always disconnected.

9. Influence on environment – on fauna and flora, also soil pollution by herbicides and pesticides

10. to introduce less fertilizers and to use water economically.

11. Protection is conducted well, plant trees, strengthen coast of Amu Darya. We regularly plant trees along the road and around the city (organized by Green Belt organization).

12. Maybe as everywhere it is lack of financing and logistic support.

13. Yes heard on the TV. If it influences negatively then necessary actions should be undertaken.

14. To use water-savings technology while land irrigating.