

Experience and Lessons Learned Brief concerning Lake Sevan

Araik Babayan, Susanna Hakobyan, Karen Jenderedjian*, Siranush Muradyan,
and Mikhail Voskanov

DRAFT

16 Dec 03

INTRODUCTION

Western scientists and environmentalists still poorly know Lake Sevan characteristics and fate. In classical western limnology textbooks Lake Sevan is rarely mentioned, except for its endemic fishes. Very few papers have been published in western journals on the Sevan issue.

The so-called *Sevan Problem* aroused since the XIX century. Primarily, the problem was how to use the water resources of the site. Lake Sevan has been recognized as a key potential water resource. High location of the lake compared to the fertile but arid Ararat Valley, lack of energy resources in the country attract the engineers to find the methods to explore the water of the lake intensively. Taking into account the water balance of lake Sevan where evaporation (800 mm year⁻¹) largely exceeds direct precipitation (360 mm·year⁻¹), an Armenian engineer named Suqias Manasserian, in his book entitled "*The Evaporating Billions and the Stagnation of Russian Capital*" (1910), proposed to use intensively the water resources for irrigation and hydropower generation. By dropping the original water level by 50 m his plan was to reduce evaporation almost 6 times by drying completely Major Sevan and leaving a shrunken Minor Sevan of about 240 km² compared to 1416 km² for the original lake. The project was further elaborated as a major Soviet project under the compulsion of the central authorities of the USSR. The project started to be implemented in 1933 when the bed of Hrazdan River was excavated and a tunnel was bored soon 40 m under the lake level. The tunnel was inaugurated in 1949 as a major achievement of socialism and the lake level started to drop at a rate exceeding 1 m year⁻¹. The water was used for irrigation and 6 hydropower stations began to produce electricity.

Very soon the problem how to use water resources has been inversed into how to use wise all natural resources and the water in particular. Yet in the 1950's became evident the ecological (and economical) consequences of extensive exploitation of the water of the lake were too undesirable to continue in the same way. Human activities have had such a negative effects as water level decrease, deterioration of a water quality, destruction of natural habitats and loss of biodiversity. Another epoch-making project started to diverse water of Arpa River through a 49 km long tunnel under the watershed line. Since 1981 the tunnel brings up to 200 million m³ water per year into to Lake Sevan. Another 165 million m³ water per year from the Vorotan

River to the Arpa River and then to Lake Sevan will bring a second 22 km long tunnel. The construction of Vorotan-Arpa tunnel expected to be fully completed in 2004.

For preservation, sensible use and reproduction of natural resources of Lake Sevan, the National Park has been established in 1978. The area was designated as a Ramsar site on July 6, 1993.

I. DESCRIPTION

General Information

The lake is the greatest inland water body of Transcaucasus Region and one of the greatest freshwater high mountain lakes of Eurasia. Before artificial outflow increase in 1933 Lake Sevan has been located at the altitude of 1916.20 m a. s. l. with the surface 1416 km² and volume 58.5 km³. Water-level decrease influenced on the living conditions of which characteristics the most important are: draining of the wetlands, worsening of the water quality, species succession, biodiversity loss. Lake Sevan is the most important source of fresh water and freshwater fish in the Transcaucasus Region. The importance of Lake Sevan in the economy of Armenia can scarcely be exaggerated: the main source of irrigation water, cheap electricity and fish, recreation, tourism. Lake Sevan and the wetlands of the basin are significant breeding, resting and wintering area for migratory waterfowl.

Location, Site Distribution and Boundaries

Lake Sevan (Figure 1) is situated in the northern part of Armenian Volcanic Highland, in

Insert Figure 1 here

Gegharkhounik Marz (province), 60 km to the North from the capital of Armenia, Yerevan. Geographical coordinates of the Lake Sevan are 40°08'N ÷ 40°49'N / 44°58'E ÷ 45°42'E. The boundary of Lake Sevan Ramsar Site is the watershed around the catchment of the lake. The borders of Ramsar Site coincide with the watershed of Lake Sevan and the external protective zone of Sevan National Park (Figure 2).

Insert Figure 2 here

Land Tenure

The Lake Sevan itself is recognized as a national treasure and is a state property. The land between the lake and surrounding circular road is under the protection of Sevan National Park. Most of the land territory of the Sevan National Park is under the responsibility of the administration of the Park (94%). The rest lands in the territory are agricultural (4%), hotels, motels and camping (2%).

All of the other parts of the basin of the lake (339,000 ha) form an external protective zone of the Sevan National Park. About one hundred settlements with total population 275,000 inhabitants are situated here. The ownerships of the land are state, regional and local administrations, communities, and private farmers and businessmen.

Management Infrastructure

The administration of Gegharkounik Marz is responsible authority for management of area. The administration is situated in the Town Gavar. Sevan National Park within its territory has three types of land zones: reserved, recreational and economic.

Management duties aren't yet clearly assigned between different governmental entities: ministries, central, provincial and local administrations.

ENVIRONMENTAL INFORMATION

Physical

Climate

High-mountain location of the site causes influence on the climate, which is cooler, compared to other areas in Armenia. On the shore of the Lake Sevan mean temperature ranges from -6°C in January to +16°C in July with average annual temperature +5°C. There are about 240 days with mean daily temperature over zero, the duration of the vegetation period is about 190 days. The quantity of sunny hours per year varied from 2600 to 2800 depending on location. Direct solar radiation is 48×10^6 Joules m^{-2} $year^{-1}$, total solar radiation is 65×10^6 Joules m^{-2} $year^{-1}$. Annual precipitation ranges from 340 to 720 mm per year of which 17% of falls in the winter, 37% in the spring, 26% in the summer and 20% in the autumn. The weather is usually windy, average speed of the wind is more than 4 $m\ sec^{-1}$ and stronger during the winter (6 $m\ sec^{-2}$) and lower in spring and autumn (3 $m\ sec^{-2}$).

Hydrology

Twenty-eight rivers and streams flow in Lake Sevan, and River Hrazdan flows out. Since 1933 the outflow of the water from the lake is artificially regulated. The hydrological balances for the different periods of water management strategy are given in the Table 1; the long-term water level changes are shown in Figure 3.

Insert Table 1 here

Insert Figure 3 here

Geology and Geomorphology, Soils

The site is young in geological scale. The age of Major Sevan is about 1,000,000 years. The age of Minor Sevan is not more than 100,000 years. The bedrocks are formed from tufa, clinker, porphyrite and limestone. Morphologically Lake Sevan consists of the deeper Minor Sevan and comparatively shallow Major Sevan.

Sevana, Vardenis, Geghama Mountain ridges up to 3598 m height are surrounding Lake Sevan from northeast, south and south-west respectively. On the northern part the watershed is close to the lake (2-3 km), the slopes are steep. On the other parts the watershed is situated on 30-40 km and the slopes are gentler. Geghama ridges on the southwestern board of the basin have a numerous signs of volcanic activity.

The soil of Sevan Ridges is brown carbonate with 30-50% of stoniness. The natural soil of the rest part of the basin is *chernozem* (black soil) with pH 5,8-6,2. On the south-western shore of Minor Sevan stony deposits predominate, on the western and southern shore of Major Sevan stoniness is 10-30%, and less than 10% on the rest part of the basin. Soil of the former bottom of the lake is on the stage of forming.

Biological

The site is situated on the junctions of Transcaucasus and Middle East Regions and has elements of different natural zones: semiarid steppe, alpine meadows, and broad-leaved forests.

Flora

In the basin of the lake about 1600 species of vascular plants (50% of Armenia's flora) has been registered. Of them 48 species are in the Red Data Book of Armenia, 6 are endemic (*Acantholimon gabrieljanae*, *Alyssum hajastanum*, *Astragalus shushaensis*, *Isotis arnoldiana*, *Isotis sevangensis*, *Ribes achurjani*).

The dominant communities of Sevan Basin are mountain steppe, sub-alpine and alpine vegetation with different species of *Astragalus* and *Acantholimon*. The most characteristic arboreal plants of Sevana Mountains are junipers (*Juniperus polycarpos*, *J. oblonga*). Remains of natural oak forests occurred on central part of Sevana Mountains. Vardenis and Geghama Mountains Sweetbrier (*Rosa canina*) and other species *Rosa sp.* are common everywhere. After water level decrease the dried areas of the former bottom of the lake has been forested by alien species of plants. Artificial forests composed by pine (*Pinus caucasica*), poplar (*Populus canadensis*, *Populus simoni*), acacia (*Caragana brevespina*, *Caragana trutex*), willow (*Salix viminalis*). Sallow Thorn (*Hippopae ramnoides*) forms almost impassable bush.

On Lake Sevan emergent vegetation exists only on limited calm areas. Pondweeds (*Potamogeton spp.*) are abundant on the depths of 2-5 m. Stonewort (*Chara spp.*) thickets cover the littoral on the depths of 4-8 m. Luxuriant development of aquatic vegetation observes on shallow coves, bogs and ponds.

Fauna

The fauna of vertebrates consists of 6 species of fishes (2 in the Red Data Book of Armenia, 2 endemic), 4 species of amphibians (none of them are considered to be endangered), 18 species of reptiles (2 of them are in the Red Data Book of Armenia), 210 species of birds (36 are in the Red Data Book of Armenia, 1 is endemic, 83 are included in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds of the Convention on the Conservation of Migratory Species of Wild Animals), 36 species of mammals (8 are in the Red Data Book of Armenia). All native fish species, Ishkhan (*Salmo ischchan*), Sevan Barbel (*Barbus goktschaikus*), Sevan Koghak (*Varicorhinus capoeta sevangi*) are in decline. Of them famous endemic Ishkhan (*Salmo ischchan*) (prince in Armenian) now is at the edge of extinction.

Amphibians are abundant everywhere, where small ponds, pools and puddles are available. The herpetofauna is more abundant on the northeastern shore of the lake and only grass-snakes (*Natrix natrix*, and *N. tessellata*) are common everywhere.

Artificial water-level decrease influenced first of all on the quantity of breeding waterfowl. From approximately 60 breeders only about 25 are registering during the last years. Eurasian Coot (*Fulica atra*), Mallard (*Anas platyrhynchos*) and endemic Armenian Gull (*Larus armenicus*) are abundant at present. Estimated quantity of Eurasian Coot is 6,000, Mallard - 5,000, Armenian Gull - 16,000 individuals during the year. The lake is important passage for migratory birds, especially in October-December (before ice cover). Such a rare birds as Great Egret (*Casmerodius albus*), Glossy Ibis (*Plegadis falcinellus*), Mute Swan (*Cygnus olor*), Whooper Swan (*C. cygnus*), Demoiselle Crane (*Grus vigro*) are registered here regularly during the migrations. Lake Sevan is important resting and wintering site for migratory waterfowl. Half century ago the area had been well known as the greatest inland breeding area for waterfowl between Black Sea and Caspian Lake. Due to the water-level drop and draining of most of wetlands the role of the site as a breeding area at present is much lower.

The most typical mammals are European Hare (*Lepus europaenus*), Red Fox (*Vulpes vulpes*), Wolf (*Canis lupus*), Weasel (*Martes foina*) and most of the rodents.

Investigations on invertebrates included only aquatic fauna: 14 plankton and 136 benthic species of different systematic groups. Plankton and benthos associations showed a close dependence on the trophic status of the lake. Recently acclimatized Long-hand Crayfish (*Astacus leptodactylus*) since the 1990's became subject of commercial fishery and export abroad, including European Community.

Socio-economic and Ecological Relationships

Archaeology and History

First settlements in this territory are dated back to the 7,000 years B. C. In the past the area was used for fishing and grazing. Although several permanent settlements occurred here from the 7th century A. C., most of the modern population came here 150 years ago mainly from Persia and Turkey. Early Christian shrine and funerary steles of 9-15th century in Noradus, churches and monastery of 9th century on the Sevan Island (now peninsula), the ruins of citadel dated back to the 6th century B. C., the cliff drawings of hunting scenes of the early Stone Age are only a few historical, architectural and archaeological relics located in the territory of Lake Sevan Basin.

Land Use

The main landscape of Lake Sevan Basin consists of mountain steppes, meadows, pastures, and crops surrounded by naked rocks on the heights over 3,000 m a. s. l. Remains of natural oak and juniper forests occurs on Sevana Mountains at the altitudes 1,900-2,200 m a. s. l. The landscape in the territory of Sevan National Park has comparatively monotonous character. It consists of artificial forest belt with a mosaic of recreational buildings. Near natural landscape remains only on Artanish Peninsula.

There are 92 settlements in Lake Sevan Basin. Of them 5 have population over 10,000 people. Villages and towns are distributed mostly around the former shoreline of the lake. Around 277,600 people (1999) inhabit Gegharkounik Marz.

Agriculture and fishery are traditional forms of activities on the territory of Sevan Basin. Main crops are wheat, barley and potato. Hard and soft forage are other agricultural plantings. Extensive cattle raising is traditional form of activity. The lands out of crops are using for grazing and haying.

The industry is less developed. Main industrial centers are Gavar and Sevan where cable, instrumental, and knitwork factories exist. Since the beginning of 1990's the industry is in permanent crisis.

Each summer Lake Sevan attracts several hundred thousands visitors due to historical, archaeological and architectural monuments ranging from the Stone Age to the late Middle Ages. The shoreline of the Lake Sevan is the most popular and traditional place for recreation and picnics. There is an interest of local administration to develop tourism industry. Several illegal forms of activities, such as poaching, unauthorized logging are negatively reflected on the present management of the Lake Sevan.

On the territory of Sevan National Park the land use is determined by zones. No activities except for research are allowed in the reserved zone. Restricted human activities are allowed on the recreation and economic zones by consent of administration of Sevan National Park.

Nature Management and Conservation

There wasn't special nature conservation management in the basin of Lake Sevan before 1978. Sevan National Park has been established on 14 March 1978 by the joint decree N^o128 of the Commonest Party and the Council of Ministers of the Armenian SSR.

Sevan National Park is state institution protecting an area of 150,100 ha, of which 24,800 ha is terrain. The core zone of the Park includes the lake and the park also incorporates a number of smaller reserves and reservations. Three main zoning areas exist: the core (reserve) zone, a recreation zone and a zone for economic use. The reserve zones are Noradus (416 ha), Lichk (645 ha), Karchaghbyur (210 ha) and Artanish (2243 ha). The boundaries between recreation and

economic zones are not established yet. The external protective zone covers the rest area of Sevan Basin. The administration of Sevan National Park is situated in Town Sevan.

The Park is managed as a research center, which monitors the ecosystems, and undertakes various conservation measures. Since 1996 Park also regulates licensed commercial fishery on Lake Sevan.

Until 1991 Sevan National Park was subordinated to the Ministry of Water Economy, after to the Ministry of Environmental Protection.

Recorded History

1,000,000 B. C. – origin of Major Sevan.

100,000 B. C. – origin of Minor Sevan by damming River Hrazdan after explosion of Volcano Eratumber.

7,000 B. C. – first settlements in the territory of Lake Sevan Basin.

V century – Armenian historian Phavstos Byuzands first mentions about fishery regulations on Lake Sevan and its tributaries.

874 – foundation of Sevan Monastery.

1830's – mass immigration and land settlement by refugees from Persia and Ottoman Empire.

1840-1900's – first hydrological, botanical and zoological studies on Lake Sevan.

1876-1878 – first scientific descriptions of endemic fish species, Ischchan (*Salmo ischchan*) and Sevan Barbel (*Barbus goktchaikus*) by Professor of St. Petersburg University K. F. Kessler.

1910 – publication of "*The Evaporating Billions and the Stagnation of Russian Capital*" by S. Manasserian; scientific substantiation of artificial water level drop for economic purposes.

1923 – establishment of Sevan Hydrobiological Station, now Institute of Hydroecology and Ichthyology of National Academy of Sciences of Armenia; start of modern studies.

1933 – beginning of artificial water level drop under the compulsion of the central authorities.

1949 – enforcement of water outflow for irrigation and energy purposes.

1956 – first public questioning the validity of water level drop after Krushchev's criticism of Stalin's cult of personality.

1959 – drainage of Gilli wetland system, the major waterfowl habitat in Armenia.

1960's – industrial boom, pollution increase

1963 – relative stabilization of water at the level ca. 18 m lower than in natural conditions.

1964 – first mass occurrence of blue-green algae *Anabaena flos aquae*.

1970-1973 – first occurrence of anoxia with presence of hydrogen sulphide and methane near the bottom area.

1976 – prohibition of endemic Ischchan fishing because of population decline.

1976-1978 – maximum nitrate level and maximum primary and secondary production.

1978 – establishment of Sevan National Park.

March 1, 1981 – inauguration of Arpa-Sevan water diversion.

December 7, 1988 – Spitak Earthquake, 25,000 victims in Armenia; destructions in Sevan Basin.

1990's – intensification of uncontrolled fishery and poaching due to lack of funds for environmental purposes.

1991-1995 – new enforcement of water outflow due to energy crisis.

1996 – stabilization of water at the level ca. 20 m lower than in natural conditions.

1996 – leading into force licensed commercial fishery on Lake Sevan.
2003 – first ever visit of LakeNet representative in Armenia.

II. THREATS TO SUSTAINABLE USE OF THE LAKE

ECOLOGICAL EVALUATION

Size and Position of the Lake

Lake Sevan is the greatest lake of Caucasus Region and one of the greatest freshwater high-mountain lakes of Eurasia. The basin of Lake Sevan makes up one sixth of the total territory of Armenia.

Biological Diversity

The biological diversity of plants is extremely high. Approximately 1600 species of vascular plants have been registered in the basin of Lake Sevan; of then 48 species are in the Red Data Book of Plants of Armenia, 6 are endemic. Vertebrate fauna consists of 276 species; of them 48 species are in the Red Data Book of Animals of Armenia, 3 endemic for the region). Fauna of aquatic invertebrates include 150 species of different systematic groups.

Naturalness

The natural development of the area is strictly depends on human activities, first of all on the water balance policy. The territory of the former bottom of the lake can be considered as a semi-natural system, which in reserve zones of Sevan National Park planned to be in future a guided natural system developing especially as a waterfowl habitat (Lake Lichk, Lake Gilly, Artanish Cove, Gull Islets). Terrestrial succession processes have not been investigated yet.

Rarity

The uniqueness of Lake Sevan is combination of its great size with high mountain location and comparatively "soft water" (mineralization = 700 mg l⁻¹). All other neighboring great lakes, Caspian (Azernaijan, Iran, Kazakhstan, Russia, Turkmenistan), Van (Turkey), and Orumiyeh (Iran) are saline. Seems, among high mountain lakes only Titicaca (Latin America, Andes) is far ahead by size (8300 km²), high location (3812 m a. s. l.) and water quality. Other peculiarity of Lake Sevan is small ratio between the catchment and surface of water mirror (3:1) comparing with other major lakes (10:1 in average).

Another unique peculiarity is high endemism of flora and fauna.

Fragility

The basin of the Lake Sevan is an area surrounded by ridges up to 1.5 km height over the surface of the lake. This means that the lake is well protected against influence from the outside of the

basin. From the other hand the small ratio between the surface of the lake and the catchment area (1:3) makes the lake especially sensitive to the internal changes. Increase of nitrogen inflow was the main reason of eutrophication of the lake (Table 2) and, as a consequence, increases of the production of zooplankton (Table 3) and zoobenthos (Table 4) as well as on qualitative composition of fish quantity of fishery harvest (Table 5). In Table 5 correct data are absent for 1992-2003 due to great discrepancy between legal and illegal fishery. Total fish harvest estimates for these years between 500 and 3000 centners. Poaching has affected not only on the number but also on the population structure of the fishes. For example, the average weight of the white fish in the spring of 1997 was 222 g while 20 years before 904 g. Transition in economy has brought from the end of 1980's a new kind of illegal activity: wood cutting for fuel, which together with the cattle grazing and tourists affected first of all on the condition of the artificial forest belt around the shoreline promoting denudation processes. The waterfowl habitats, especially of Armenian Gull (*Larus armenicus*), largely depends on the water level and its seasonal and annual changes.

Insert Tables 2-5 here

Typicalness

The flora of the basin is typical to the highlands of the Transcaucasus Region. Here seems to be the greatest diversity in plants. Along the shoreline of the lake the greatest artificial woodland of the country is situated which gives a number of interesting examples of natural and human affected successions. Aquatic associations (plankton, benthos, ichthyofauna) are qualitatively poor with only a few dominant species, which simplified studies on ecological relationships (food web, etc.).

SOCIO-ECONOMIC EVALUATION

Aesthetic, Cultural and Religious Value

Lake Sevan has always been a popular place for holidaymakers. Beautiful landscapes, cool water, fresh air and close location to the capital attract dozens thousands people every weekend during hot summer days. Archaeological, historical and architectural relics from the early Stone Age until the late Middle Ages located in the basin of the lake are of great importance for whole Armenians living in the country and abroad. In addition a theological seminary of Armenian Apostolic Church is recently established on Sevan Peninsula.

Socio-economic Values

Lake Sevan and its basin provide matters of abiocoen origin, as well as of animate nature (both dead and living), such as peat, plants and animal products. These products are sand, water, peat, fuelwood, hay, herbs and potherbs, mushrooms, berries, crops, fish, gamebird, cattle, opportunities for recreation, tourism, bird watching, education, research and aesthetic appreciation, etc. All these products have *direct use values* - because they have market price.

As of 1 January 2002, in Lake Sevan the water resources estimate 32.921 km³. This water is quite suitable for cattle watering and irrigation and with minor purification also for drinking. Lake Sevan is main source of water for thermoelectric power generation, manufacturing, and other industrial uses.

In the Lake Sevan Basin are situated a number of mineral springs, of them of commercial importance are *Sevan* and *Lichk*. Mineral waters are of great importance for the economy of the country and make significant part of export.

The largest sand and gravel deposits of aquatic origin are situated mainly on the eastern shore of Lake Sevan.

The total volume of commercial peat in Lake Sevan Basin is around 30 mln m³. Main commercial excavation is near Village Torfavan. Annual amount of extracted peat estimated around 50 thousands tons. Peat is used in agriculture (50%; fertilizer, substrate in horticulture, bedding material), balneology (5%; mud-baths), as fuel (45%).

In the past reeds had been harvested for such kind of everyday necessities as thatching and structural building (in combination with the clay). Present uses of reeds are crafts, bedding material (litter), fuel.

Flexible willow branches utilized for fish-traps (*trap*) and basket binding. Willow wood and other smaller-sized trees and bushes are used for fuel.

Some mushrooms are used for food, for example *Coptinus comatus*, *Cortinarius sp.* A number of plants are collected for hay, food (*Butomus*, *Nymphaea*, *Nasturtium*, *Rumex*, *Falcaria*, *Asparagus*), medicine (*Althaea officinalis*, *Bidens tripartida*, *Gnaphalium uliginosum*, *Glycyrrhiza glabra*, *Menyanthes trifoliata*, *Mentha longifolia*, *Nuphar luteum*, *Ononis arvensis*, *Polygonum hydropiper*, *Plantago major*, *Tussilago farfara*, *Valeriana sp.*), bouquets.

Lake Sevan is especially significant for fishery. Among fish species of commercial importance in Lake Sevan Basin are Whitefish, Ishkhan, Crucian Carp and Koghak.

The waterfowl traditionally is a subject of commercial (in the past) and sports hunt. Of game birds the most important are puddle ducks (Mallard and Teal above all), coot and snipes.

A number of mammals are hunted for fur and meat.

The marsh frog has potential value for export.

Some benthic invertebrates, such as *Oligochaeta*, *Amphipoda*, larvae of *Chironomidae* (*Diptera*) and in lesser extend *Ephemeroptera*, *Trichoptera* are collected for sale as food for aquarium fish.

Surroundings of lake and such types of wetlands as mires, bogs, marshes, floodplains provide a space for grazing.

Lake Sevan and its basin have a number of areas of special beauty (Artanish Peninsula, Sevan Peninsula, Gull Islets, Lake Lichk, Noradus Fishponds, Gridzor Rocks, etc.) and are of existing or potential value for recreation, tourism and bird-watching development.

Environmental Legislation of Armenia

A number of issues need to be clarified under the existing legislation, particularly the rights and responsibilities of public and private sectors, and the role and participation of the local communities and non-governmental organizations in management of protected and other areas, and open water, including Lake Sevan, in particular. In addition, clear plans for conservation regimes and opportunities for sustainable use are not defined clearly. The current system of protected areas is restrictive and might benefit from a broader range of types being recognized. A range of environmental laws exists in Armenia. However, many of these laws are not effective enough and cannot be enforced properly at present. Some of the laws are now outdated, and would need revision to be brought into line with current socio-economic and political situation, and land privatization in particular. Up till now only a few specific regulatory acts have been adopted under these laws.

An important shortage of Armenian environmental legislation is that many of the laws do not correspond to international standards, particularly, to commitments taken upon accession to the Ramsar Convention and Biodiversity Convention. In particular, the Law on Especially Protected Natural Areas is not corresponding to the IUCN categories of protected areas (2000) to the status of different protected areas.

Constitution of the Republic of Armenia (1995)

Environmental issues are mentioned in §8 and §10. According to §8 any utilisation of private property should not cause damage to environment. According to §10 the state is responsible for protection of environment and reproduction of biological resources.

Codes

The Criminal Code (1961) regulates criminal amenabilities for tort, particularly violations of utilisation of natural resources and protection of environment.

The Tort Code (1985) regulates administrative responsibilities for crime, particularly crime concerned with natural resources and environment.

The Forest Code (1994) regulates public relations in the fields of forest management, reproduction, protection and utilization.

The Land Code (1991/2001) regulates public relations in the fields of land management, fertility, increase of efficiency of land use, different aspects of environment protection.

The Civil Code (1998) particularly regulates public and legal aspects of the use of natural resources and environmental protection.

The Ore Code (2002) defines ore as part of the earth's crust under the soil layer and in case of absence of soil layer form the surface, below the bottom of the stagnant and flowing water bodies. Treasures of the soil are among others underground fresh and mineral water, sediments of the stagnant and flowing water bodies.

The Water Code (2002/1992) aims on protection of national water resources, satisfaction of public needs in water supply through effective management of exploitable water and protection of natural water bodies. The Code defines the principles of management, use and protection and of water resources and aquatic systems, regulates issuing of permits for utilization of water resources. According to the Code, water resources are all surface and underground water, including brooks, rivers, springs, wetlands, lakes, ponds and fishponds, glaciers, water-bearing layer, other water bodies, short-term water resources. All water resources in Armenia are state property. New Water Code aims to take into account socio-economic and political changes of the last decade, particularly with regard to land privatization and the establishment of private sector.

Laws

The Law on Principles of Environmental Protection (1991) regulates the principles of national environmental policy and assigned to secure protection of environment and regulates utilisation of natural resources: ore, water, air, flora, fauna.

The Law on Especially Protected Natural Areas (1991) regulates formation, organization, conservation and utilization of especially protected natural areas. According to this Law the following types of especially protected natural areas are in Armenia: state (strict) reserves, national parks, state (game) reserves, natural monuments.

The Law on Protection the Atmosphere and Air Quality (1994). The subject of the Law is maintenance of atmosphere and air quality, reduction and prevention of chemical, physical, biological and other negative influence.

The Law on Environmental Impact Expertise (1995) regulates expertise of impact of proposed actions or proposed projects, general layouts or comprehensive schemes on environment.

The Law on Payments for Nature Protection and Use of Natural Resources (1998) defines concept of payments for nature protection and use of natural resources, circle of payers, types of payments, regulates procedure of payments and stock-taking, amenability for breaking of this Law.

The Law on Flora (1999) determines scientifically grounded protection, conservation, utilization and regeneration of plant resources. The Law aims to regulate public relations in the sphere of conservation and use of plant resources.

The Law on Fauna (2000) determines scientifically grounded protection, conservation, utilization and regeneration of animal resources. The Law aims to regulate public relations in the sphere of conservation and use of animal resources.

The Law about Lake Sevan (2001) regulates public relations in conservation, restoration, reproduction, natural development and utilization of ecosystems of Lake Sevan, its catchment and economic zone.

The Law about Approval of Annual and Complex Measures on Conservation, Restoration, Reproduction, and Use of the Ecosystem of Lake Sevan (2001) approves annual and complex measures on conservation, restoration, reproduction, and use of water, plant and animal resources of Lake Sevan and its basin, including quotas.

The Law on Examination of the Ore for the Purposes of Excavation of Minerals (2002) regulates the policy of granting concessions in the field exploitation of minerals.

The Law about Local Government (2002) determines responsibilities of institutions of local governing, particularly responsibilities for management of territories of communal ownership.

Related Government Decrees

Government decree № 125 of 14 March 1978 about establishment of Sevan National Park.

Government decree № 23 of 26 January 1996 on approval of the “Regulations of commercial fishery in Lake SevanPark”.

Government decree № 864 of 30 November 1998 about margins of payments for use of natural resources.

Government decree № 927-N of 30 May 2002 about reorganisation of Sevan National Park into state non-commercial organisation and approval of the “Regulations of Sevan National Park”.

Government decree № 1380-N of 22 August 2002 on approval of the “Regulations of issuing licenses and signing a treaties on use of animal resources for agricultural and insutrial purposes.

International Environmental Treaties

Convention on Wetlands of International Importance especially as Waterfowl Habitat

Recognizing the true values of wetlands Armenia became a Contracting Party to the Ramsar Convention on 6 July 1993 (with entry into force on 6 November 1993), less than two years after independence and first among the countries of the former Soviet Union. The Administrative Authority for the Convention is the Ministry of Nature Protection. Two sites were designated for the List of Wetlands of International Importance at the time of Accession:

<i>Site name</i>	<i>Designated</i>	<i>Area</i>	<i>Co-ordinates</i>
Lake Arpi	July 6, 1993	3,149 ha	41°03'N 043°37'E
Lake Sevan	July 6, 1993	489,100 ha	40°24'N 045°17'E

The Lake Arpi Ramsar Site includes the surface of the lake (2,000 ha) and surrounding bogs, land and tributaries (1,149 ha). No part of Lake Arpi Ramsar Site is designated as a national protected area. The site supports to the following Ramsar Criteria of Wetlands of International Importance:

- (1a)** Physical and ecological conditions are similar to other high-mountain lacustrine water-bodies of Transcaucasus Region, i. e. lakes Paravani, Khanchali (Georgia), Chaldir (Turkey).
- (2d)** Here is situated the second largest breeding colony of Armenian Gull (*Larus armenicus*) (Red Data Book of Armenia). The site is unique by its comparatively natural communities of specific high-mountain meadows with such a rare and endangered species as Siberian Iris (*Iris sibiricus*), Slender Gladiolus (*Gladiolus umbricatus*).

- (3c) The area supports to the second greatest breeding colony of Armenian Gull in the country which account ca. 1/3 of the total population.

The Lake Sevan Ramsar Site supports to the following Ramsar Criteria of Wetlands of International Importance:

- (1c) The lake is of crucial importance in the economy of the country and plays a great role in the natural functioning of own basin and River Razdan (Armenia) - River Arax (Armenia, Azerbaijan, Iran, Turkey) - River Kura (Azerbaijan, Georgia) - Caspian Sea (Azerbaijan, Iran, Kazakhstan, Russia, Turkmenistan) system.
- (1d) Lake Sevan is the greatest inland water body of the Transcaucasus Region, the greatest freshwater lake in the Minor and East Asia and one of the greatest high mountain freshwater lakes in the world.
- (2a) The lake and its basin supports at least 48 species of vertebrates and 48 species of plants included in the Red Data Book of Armenia, i. e. 48% of rare, vulnerable and endangered fauna and 12% of flora.
- (2b) In the basin of the lake about 1600 species of vascular plants has been registered, i. e. 50% of Armenia's flora. The fauna of vertebrates consists of 6 species of fishes (21% of Armenian ichthyofauna), 4 species of amphibians (57% of Armenian batrachofauna), 18 species of reptiles (42% of Armenian herpetofauna), 210 species of birds (60% of Armenian ornithofauna), 38 species of mammals (45% of Armenian mammofauna).
- (2d) Such kind of plants as *Isatis arnoldiana*, *Alyssum hajastanum*, *Acantolimon gabriljiana* have not been found elsewhere in the world except the basin of Lake Sevan. Of fish species the famous Ishkhan (*Salmo ischchan*) and Beghlu (*Barbus goktchaikus*) are endemic.
- (3a) During the autumn migration the area supports from 10 to 30 thousands waterfowl.
- (3b) It regularly supports during the seasonal migrations substantial numbers (until 20 thousands) of *Anatidae*.
- (3c) The area regularly supports to more than the half of the total population of Armenian Gull (*Larus armenicus*).
- (4a) Besides the endemic fish Ishkhan and Beghlu the lake and its tributaries support during the whole life cycle an endemic subspecies Sevan Koghak (*Varicorhinus capoeta sevangi*).

Other International Treaties relating to Lake Sevan

Convention on Biological Diversity (UNCBD, Rio de Janeiro, 1992) – Armenia is Contracting Party since 1993. The Lake Sevan Basin supports 46% of flora and fauna diversity in Armenia.

United Nations Framework Convention on Climate Change (UNFCCC, Rio de Janeiro, 1992) – Armenia is Contracting Party since 1993. In Lake Sevan Basin is situated the largest deposit of peat in Armenia, Torfavan.

Convention concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention, Paris, 1972) – Armenia is Contracting Party since 1993. Lake Sevan is one of the most important cultural and natural heritages of Armenia although not yet designated worldwide.

United Nations Convention to Combat Desertification (UNCCD, Paris, 1994) – Armenia is Contracting Party since 1997. Most of the territory of Lake Sevan Basin is subject to severe, strong and medium desertification.

Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus, 1998) – Armenia is Contracting Party since 2000

Convention on the Conservation of European Wildlife and Natural Habitats (Berne, 1979) – Armenia is Contracting Party since 2003

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Washington, 1973) – membership is under consideration

Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn, 1980) – membership is under consideration. Lake Sevan is the largest internal water body between Black Sea and Caspian Lake and support dozens of thousand waterfowl during seasonal migration.

UN-ECE Water Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UN-ECE Transboundary Waters, Helsinki, 1992) – membership position is not considered yet. Lake Sevan is part of Kura-Arax River Basin shared with Armenia, Azerbaijan, Georgia, Iran and Turkey.

Government Programs, Action Plans, Reports

All programs, action plans, reports carried out by the Ministry of Nature Protection with measures proposed for Lake Sevan are listed in Table 6 with a brief description of the status of measures projected and implemented. It is evident that there are inadequate to the current needs of Lake Sevan.

Insert Table 6 here

Education and Public Awareness

Protection of the Lake Sevan requires the cooperation of all government institutions responsible for management and exploitation of the nature resources and local communities with the Sevan National Park. Unfortunately very often there is not agreement between the ministries and even different government organizations within the one ministry. Although the administration of the Sevan NP makes efforts to involve the local population in the active protection yet here still are more problems than benefits. A permanent exhibition showing examples of the flora and fauna of the basin of the lake, the history of the site is situated in the Town Sevan. Many publications on the Lake Sevan are available in different languages. However the most recent popular scientific publication is the booklet on the Sevan National Park issued in 1989.

Public Use / Wise Use / Recreation

It is difficult to exaggerate the role of Lake Sevan and its basin for Armenian country. At present in the basin of Lake Sevan are 92 settlements with total of 277,600 inhabitants (1999) and population density 52 per km². Main economic activities in the basin are first of all agriculture and fishery. Approximately 20% of country livestock is raised in the basin. About 90% of fish catch of Armenia is from Lake Sevan. As a result of economic crisis industrial production is practically ceased. Development of intensive agriculture and industry, service facilities for tourism and recreation is desirable while ensuring that ecological damage is minimal.

Research and Study

Research and study are the only human activities, which could be permit by the SNP authorities on the territories of the preserve zones. Lake Seven is one of the well-investigated large lakes of the world although poorly known in the West due to language barrier. The most important studies had been carried out in the field of hydrology and hydrobiology. Many aspects of the biology have a history of long term monitoring. The inventory of many systematic groups of animals and plants is already completed. There are steel many issues to be studied, particularly the ways of the restoration of the waterfowl habitat, recreation management, etc.

Potential Values

Lake Sevan is the only strategic potential source of (near) drinking quality water in the whole Caucasus Region. The area has potential of further development of fishery, including crayfish cthch. Other potential values of the area are its cultural and natural heritage attractive for tourism development.

INVENTORY OF PROBLEMS

Internal Natural Factors

Of internal natural factors most important are and should be always considered physical and chemical composition of the water, transparency, oxygen and temperature regime, qualitative and quantitative development of plankton and benthos, fish stocks.

Internal Human Induced Factors

It is evident the trophic status of the lake largely depends on human impact on water balance and pollution. The water volume has been artificially reduced from 58.4 in 1933 to 33.0 km³ in 2002. Pollution inflicted from sewage, industry, agriculture has been sharply increased since 1960's. In spite of this the changes of trophic level of the lake sometimes are unpredictable.

External Natural Factors

Weather impact, particularly droughts cause serious impact especially during breeding period of fish and waterfowl. For example, drying up of rivers and wetlands brings to worsening of spawning and nesting conditions of fish and waterfowl.

External Human Induced Factors

The ecosystem of Lake Sevan Basin is comparatively well separated from external human induced factors due to bordering ridges, which are 1.5 km higher than the lake. Since 1981 up to 200 million m³ year⁻¹ of water from Arpa River flows to Lake Sevan by tunnel constructed under the watershed of Vardenis Ridge. The impact of 'alien' water on Lake Sevan seems, hasn't pronounced effect.

Factors Arising from Legislation and Traditions

Imperfection of legislation puts obstacles in the way of management of the lake, and Sevan National Park in particular.

Many forms of traditional activities, such as **reed harvesting, eatable and pharmacological plant collecting**, buffalo breeding are forgotten. The return of traditional rights to the local inhabitants after ¾ century long communist experiment should be carried out in combination with the nature protective measures.

One of the first but important steps in this direction is bringing into the force licensed traditional fishery in 1996. However, current licensing system with its bureaucratic obstacles and high margins of payments for use of natural resources is far to be perfect.

Physical Considerations

In 1980 the Council of Ministers of the Armenian SSR has decided to increase the water level of Lake Sevan on 6 m during 25 years. The decision was based on scientific prognosis made by the scientists of Sevan Hydrobiological Station. According to the prognosis, water level increase at least on 6-8 m is important to bring environmental conditions to near natural. Already 5 years later became clear this ambiguous goal was failed. However, World Bank funded *Lake Sevan Action Program* discussed 2 options based on cost-benefit analysis: 3 m water level increase during 15-34 years and 6 m during 31-85 years. It should be mentioned that there is no evidence 3 m water level increase (supported by the World Bank) could bring to substantial improvement of environmental conditions in Lake Sevan.

Available Resources

Lake Sevan Action Program considers Implementation Program of 4 Phases (**Table 7**). Total cost of the Program is US\$ 30,000,000. More US\$ 15,000,000 is important for completion of Vorotan-Arpa tunnel construction, and more US\$ 100,000,000 for construction of Eghvard Reservoir for accumulation of Lake Sevan water for irrigation purposes.

From this amount only funds for Vorotan-Arpa tunnel are secured.

Government order exist for reproduction of endangered endemic fish species Ishkhan and Koghak, total AMD 9,975,000 (US\$ 17,138). State funds for Sevan National Park are enough only for salaries of the staff and solutions of top-priority problem.

MAJOR THREATS (IMPACT ASSESSMENT ANALYSIS)

High vulnerability of mountain aquatic ecosystems creates difficulties in the sustainable use and requires constant realization of complex protective measures. All major threats to Lake Sevan are human induced. At the heart of conflicts is underestimation of economical and especially ecological values and features. The conflicts itself comes from diverse views on the values by various stakeholders in decision-making process. The analysis of numerous conversations and interviews with people concerned shows that depending on position of given person, his position and relation with the lake, his approach to the values could differ and even contradict to public opinion. This could be because of differences in understanding, judgments, preferences, priorities, precedence and positions.

Water Loss

Water loss is the most important threat. Artificial increase of the outflow from Lake Sevan with the purpose to obtain hydropower and irrigation water for Ararat Valley farmlands resulted in the lake level drop on 19.88 m (from 1916.20 to 1896.32 m above sea level as of January 1, 2002), decrease of the volume from 58.5 to 32.9 km³ (44%), and the surface from 1416 to 1236 km² (13%).

Water Balance Disturbance

Water balance disturbance happens because of uncontrolled water use for hydropower (long-term or of many years) and irrigation (short-term or seasonal). The consequence of long-term water balance disturbance is deterioration of ecological characters of Lake Sevan in all levels. An example of short-term water misbalance is River Vardenik, which is completely drained in drought summers because of flow diversion for irrigation. The river is of virtual importance for population of fish Koghak (*Varicorhinus capoeta sevangi*)

Soil Deterioration

Exposure of soils to drying in during water level drop brought to their salination. Areas of lands exposed to salination situated mainly along southern shoreline.

Soil Erosion

Soil erosion on riverbanks is a natural process which is pronounced while human induced - on the undercurrent of some tributaries of Lake Sevan situated on the soft sandy soils of the lake's former bottom: River Dzknaget, River Gavaret, River Tsakqar, River Lichk and River Masrik. During the last 60 years abovementioned rivers have formed 5-13 m deep U-shape valleys. Soil

erosion augment significantly sedimentation rate in Lake Sevan. Soil erosion frequently aggregated by *Deforestation*.

Sedimentation

Sedimentation is another natural process, which becomes serious when enforced by human beings. Especially high sedimentation rate occurs in the mouths of rivers Gavaraget and Lichk.

Mudflows

Seasonal and regular rivers and creeks of the northeastern part of Sevan Basin, River Pambak, River Dara, Creek Babajan, Creek Jil, Creek Gyuney, Creek Shishkaya run highest degree danger of mudflows. Mudflows occurrence on mentioned rivers is once in a 3 years and more often.

Waterlogging

Only 100 ha are under the water logging in Sevan Basin. The gravity of the problem is that waterlogging takes place directly on the territories of villages Lichk and Artsvaqar.

Pollution

Surface water in Armenia, and especially in Sevan Basin generally seems to be of remarkably high quality as compared to international standards. Groundwater resources are very well protected from pollution. Spring water usually is of good quality and can be used for drinking without further treatment. However, without proper attention the situation could change easily. The discharge of industrial pollutants, domestic sewerage and agricultural run-off into the lake increases the organic loading. Decomposition of organic matter decreases the oxygen concentrations of the water body. In Lake Sevan in the 1970's oxygen saturation in the bottom area water of the profundal during the stratification period were close to analytical zero. Worsening of oxygen conditions may seriously contaminate the water, endangering the plant and animals living.

Dumping of garbage is a big problem for urban areas (Sevan, Gavar, Martuni).

Over-exploitation

Extensive use of water resources associated with increased pollution of Lake Sevan had an effect on the ecosystem of the lake, from physical conditions to primary production and fish community.

Livestock overgrazing on the Lake Lichk area brought to degradation of vegetation and serious deterioration of the waterfowl habitats.

Uncontrolled fishery in Lake Sevan brought to serious decline of fish stocks. As a result of over-exploitation 2 out of 4 subspecies of Ishkhan (*Salmo ischchan*) have been extricated.

Factor of Disturbance

People and cattle access in the habitats influenced adversely on the waterfowl. Waterfowl is especially sensitive to the factor of disturbance during the breeding period. Evident example is comparison of two adjoined colonies of Armenian Gull on the islet and on peninsula in Lake Sevan. The first one is fully isolated from the mainland while the second is easily accessible by vacationists and cattle. In 2000 on the islet 84% of hatches was successful, and only 8% on the peninsula.

Deforestation

Deforestation is comparatively new threat originated in late 1980's - early 1990's during the blockade and energy crisis. Deforestation of riverbanks increases soil erosion processes as it has happened on River Lichk.

Invasive Species

Invasive plant and animal species are well known for their destructive impacts. Sea-buckthorn (*Hippophae rhamnoides*) occupies sandy soils around Lake Sevan making sometimes almost impassible stands.

Introduction of Crucian Carp (*Carassius auratus*) in Lake Sevan in 1970's influenced negatively first of all on the quantity of endemic Koghak (*Varicorhinus capoeta sevangi*). Crusian Carp's and Koghak's fries are food competitors.

There is also the constant risk of new introductions as it had been happened recently with the Muskrat in Lake Arpi. Appearance of Muskrat in Lake Sevan could have unpredictable consequences.

Health Problems

Presently the epidemiological and epizootic situation on the entire territory of Armenia is not the best. In this regard it is necessary to conduct methodologically correct, full prophylactic measures. The biological methods of controlling the numbers of disease carriers and water purification, as well as sanitary-explanatory work should be of main importance. During the contact with static and unpurified water an increase in the incidence of transmissible diseases can be expected. This already happened in a number of settlements around the foul canals of degraded drainage system on River Gavaraget downstream Town Gavar. Here a few events of cholera and dysentery had been registered between 1991 and 2000. Other wetlands seem secured against human diseases.

III. LESSONS LEARNED

Approach to Investments

The process of application of economic instruments for investments in environmental issues through the legal reforms actively developed since the independence (**2.1.3. Environmental Legislation of Armenia**). However, it is obvious there is no possibility for substantial investments in Lake Sevan from internal, whether state or private sources in the visible future. Main efforts should be directed on international funding organizations and Armenian Diaspora. In parallel the Government should be the guarantor of investments and purposeful use of funds.

Capacity Building Efforts

Management duties aren't yet clearly assigned between different governmental entities: ministries, central, provincial and local administrations, Sevan National Park. In practice this means parallelism and even reduplication of responsibilities, unreasonable bureaucratic obstacles and, as a result, gaps in daily management issues with far-reaching implications.

The positive thing is that the objectives of Phase I of *Lake Sevan Action Program* are partly achieved: Commission on Lake Sevan is established, the laws 'about Lake Sevan' and 'about approval of annual and complex measures on conservation, restoration, reproduction, and use of the ecosystem of Lake Sevan' are passed by the National Assembly. A lot more should be done to achieve the objectives of *Lake Sevan Action Program*, and the main obstacle is restricted funds.

Citizen and Stakeholder Participation in the Design and Implementation of Programs

Lake Sevan is focus of attention of all citizens of Armenia and Armenian Diaspora. People can't imagine even simple existence of the country without Lake Sevan. Nevertheless the following entities are acting as primary stakeholders: Government of Armenia, local communities, administration of Gegharquniq Marz, Sevan National Park, NGO's, research and educational institutions, peasants, fishermen, vacationers.

Public participation include such activities as public hearings, participation of the representatives of stakeholders in environmental impact expertise, in designing and implementation projects and programs, in different commissions acting in public authorities. Sounds strange but the initiative in actions envisage cooperation with state authorities belong to state authorities that are in charge of provision of public participation and provide all relevant information. Very often this brings to the situation when public participation considered simply as formal obligation, just to tick off.

Sustainability of the Lake Management Institutions

Many institutions are engaged in different aspects of Lake Sevan management: elected and appointed administrative authorities, scientific-research institutes, conservancy organizations, consumers, etc. Among them Sevan National Park under the Government of the Republic of Armenia and direct governance of the Ministry of Nature Protection should take a leading role and overall responsibility for coordination of Lake Sevan management.

Regrettably, this is far to be reality for the following reasons:

- absence of legal ground
- weak human resources
- weak material resources
- poor scientific equipment
- poor technical equipment
- lack of support of local inhabitants
- lack of self-dependence in operative decision-making

Linkage of the Lake Management Program to the Broader National and Regional Water Resources Management Reforms

Lake Sevan management program is closely linked with ongoing *Natural Resources Management and Poverty Reduction Project*, where Gegharqouniq Marz is one of two case areas of project implementation. In frames of the project the management plan for Sevan National Park should be prepared and implemented.

In *Biodiversity Strategy and Action Plan of Armenia* Sevan is mentioned in *Strategic Component A: In Situ Conservation*: provide technical assistance and equipment for Sevan National Park II, provide resource material for library in the Sevan National Park I, conserve and rehabilitate key wetland ecosystems including Lake Sevan III, develop and implement individual action plans for conservation of key endangered species including Ishkhan II; in *Strategic Component C: Sustainable Use*: review and revise, if necessary, existing regulations regarding commercial fisheries in Lake Sevan I, assess impacts of recreational activities in the Lake Sevan watershed on biodiversity I, develop criteria and regulations for recreational use in the Lake Sevan watershed I; in *Strategic Component G: Research*: record and monitor changes in biodiversity in Lake Sevan II, record and monitor changes in biodiversity in Lake Gilli.

Here I indicates budget range US\$1,000-100,000; II – US\$100,000-500,000; III – over US\$500,000. Activities already undertaken are underlined; successful activities – double underlined (no such activities).

Indicators and Monitoring and Evaluation Mechanisms of Environmental Quality and Economic Status

A number of indicators might be suggested which improvements or deterioration of environmental quality and economic status can be assessed against:

- a. water quality
- b. water quantity
- c. levels of pollution, including phosphate and nitrate
- d. primary production rate (phytoplankton and macrophytes)
- e. secondary production rate (zooplankton and benthos)
- f. commercial fish stocks
- g. condition of habitats, and wetland in particular

- h. number of threatened species
- i. number of Ishkhan
- j. socio-economic factors

Monitoring and evaluation mechanisms should consider a standard circular framework for assessment:

- k. Extent the planned activities achieved their outputs
- l. extent the overall objectives been achieved through these activities
- m. initial information available
- n. other information has become available
- o. lessons have been learned
- p. existing gaps
- q. correlation of initially planned activities

The Relevance and Quality of Scientific Research Being Undertaken

The reasons of deterioration and results of scientific research addressed to improve environmental conditions of Lake Sevan and its catchment are the critical prerequisites for decision-makers for actions undertaken for prevention or mitigation of negative factors. Lake Sevan is in the focus of continual scientific observations since the establishment of Sevan Hydrobiological Station in 1923. Since then, the staff of this institution has always been among most advanced investigators of internal waters in the USSR. Other institutions involved are Institute of Geology, Institute of Botany, Institute of Zoology, Yerevan State University. Valuable data on quantitative and qualitative changes of large number of environmental indices of Lake Sevan have been accumulated and analyzed. In particular, long-term correlation between primary production (phytoplankton and macrophytes), secondary production (zooplankton and zoobenthos) and fishery has been found.

Regrettably, most of studies were suspended in 1992 because of lack of funds. Modern scientific research towards environmental issues requires comprehensive approach, advanced methods and technical supplies, scientific prediction of renewable biological resources and possible negative phenomena, and, of course, **significant capital investment**. At this stage the major problem of Lake Sevan management is lack or complete absence of scientifically established data on the rates of primary production, fish stocks, etc.

IV. REFERENCES AND FURTHER READING

Adamian, M. S., D. Klem, 1999. Handbook of the birds of Armenia. Yerevan: American University of Armenia: 649 pp.

- Agricultural Map of Armenian SSR, 1984. Main department of geodesy and cartography of the Council of Ministers of the USSR. Moscow-Yerevan: 189 pp. [in Russian]
- Armenia – Country Study on Climate Change. First National Communication of the Republic of Armenia under the United Nations Framework on Climate Change. 1999. Ministry of Nature Protection. Yerevan: 66 pp.
- Armenia – National Environmental Action Program 1999. Ministry of Nature Protection. Yerevan: 70 pp.
- Barseghyan 1990. Wetland vegetation of Armenian SSR. Academy of Sciences of Armenia. Yerevan: 353 pp. [in Russian]
- Biodiversity of Armenia: First National Report 1999. Ministry of Nature Protection. Yerevan: 126 pp.
- Biodiversity Strategy and Action Plan of Armenia 1999. Ministry of Nature Protection. Yerevan: 114 pp.
- Climatic Map of Armenian SSR, 1975. Academy of Sciences of Armenia. Yerevan: 88 pp. [in Russian]
- Gabrielyan, H. (ed.), 1984. Erosive and mudflow phenomena in Lake Sevan basin. Issues of Geography. Issues 1-2. Yerevan State University: 248 pp. [in Russian]
- Jenderedjian, K., 1997. Draft Management Plan for Lake Sevan. RIZA: 26 pp.
- Jenderedjian et al., 1999. Inventory of Armenian Ramsar sites: in search of ways for restoration of the lost and rehabilitation of degraded wetlands, especially as a waterfowl habitat. Final Report. Department of Especially Protected Natural Areas. Yerevan-Sevan-Arpi: 142 pp.
- Jenderedjian et al., 2001. Implementation of the Ramsar Strategic Plan in Management of Wetlands in Sevan National Park. Final Report. Professional and Entrepreneurial Orientation Union. Yerevan-Sevan: core 125 pp., addendum 72 pp.
- Lake Sevan Action Program. Main Report 1999. Ministry of Nature Protection. The International Bank for Reconstruction and Development/The World Bank: 47 pp.
- Manaserian S., 1910. The Evaporating Billions and the Stagnation of Russian Capital. In Kavkazski Vestnik. [in Russian]
- Mkrthcyan, S., L. Vardanyanc, A. Gabrielyan, I. Maghaqyan, K. Paffengolc (eds.), 1969. The Geology of Armenian SSR. V. IX. Mineral waters. Yerevan: 523 pp.
- Pipoyan, S., E. Tigranyan, 1998. List of fishes from the Armenian waterbodies. Biological Journal of Armenia v. 4 (51): p. 258-265. [in Russian]

Takhtajyan, A. 1954. Map of Flora districts of Armenian SSR. In Red data Book of Armenia. Plants. Academy of Sciences of Armenia. Yerevan: p. 30. [in Russian]

Zakharyan 1960. Peat excavations of Armenian SSR. In Collection of scientific works of Armenian Agricultural Institute, I. Yerevan: p. 249-251. [in Russian]

CONTACTS

*Contact person:

Karen Jenderedjian
Head, Division of Animal Resource Management
Agency of Bioresource Management
Ministry of Nature Protection
Government Building 3, Republic Square
375010 Yerevan, Armenia
Tel.: 374 1 568027
E-mail: jender@arminco.com

Table 1. Lake Sevan Water Balance in different years in 1,000,000 m ³ year ⁻¹						
Components of balance	<i>1927-1933</i>	<i>1949-1962</i>	<i>1970-1979</i>	<i>1984-1990</i>	<i>1992-1997</i>	<i>1998-2003</i>
Surface inflow	811	669	774	990	1144	986
Precipitation	509	475	479	486	466	498
Underground inflow	31	48	56	81	65	76
Summary income	1351	1192	1309	1557	1675	1560
Surface outflow	42	1383	430	329	831	167
Evaporation	1136	1041	1039	1102	1081	1262
Underground outflow	84	26	9	9	15	20
Summary expenditure	1262	2450	1478	1440	1927	1431
Discrepancy	+89	-1258	-169	+117	-252	+129

Table 2. Values of primary roduction
in Lake Sevan in kJoule m⁻³ year⁻¹

Years	Production
1939	2400
1947	3500
1959	4610
1961	9700
1962	12500
1966	23300
1967	12900
1968	10700
1969	10400
1972	8900
1974	20100
1975	16300
1976	29590
1977	31090
1978	23870
1979	12790
1980	16640
1981	13350
1982	12480
1983	8680
1974	20100
1984	12480
1985	8220
1986	13260
1987	10660
1988	13310
1989	11390
1990	12570
1991	14670
1995	23000

Table 3. Average annual biomass and production of zooplankton of Lake Sevan and production rate (*P/B*)

Years	Biomass, kJoule m ⁻² year ⁻¹	<i>P/B</i>	Production, kJoule m ⁻² year ⁻¹
1937	40.7	16.6	674
1947	47.2	20.3	960
1957	29.6	16.1	478
1961	36.5	18.6	680
1962	32.2	21.6	695
1965	38.5	19.6	753
1966	49.6	18.0	868
1967	26.4	21.4	566
1968	32.8	20.6	675
1969	31.1	17.8	554
1972	36.2	24.7	895
1974	51.1	21.7	1108
1975	85.0	11.1	947
1976	114.1	21.9	2504
1977	43.3	17.9	775
1978	100.1	12.1	1216
1979	60.0	17.7	1063
1980	58.6	20.7	1212
1981	40.3	15.6	629
1982	39.2	13.3	520
1983	25.9	15.9	413
1984	21.0	26.5	556
1985	32.6	19.3	629
1986	40.3	14.2	571
1987	42.5	20.3	861
1988	31.3	12.4	388
1989	16.0	15.2	243
1990	48.0	13.6	652
1991	62.2	13.3	826

Table 4. Average annual biomass (g m^{-2}) of different systematic groups of zoobenthos of Lake Sevan

Years	Oligochaeta	Leeches	Gasteropods	Bivalve	Gammaridae	Ephemeroptera	Trichoptera	Chironomidae	Whole zoobenthos
1928	1.64	0.41	0.03	0.12	0.62	0.01	0.05	0.38	3.26
1938	2.05	0.51	0.12	0.31	0.56	0.01	0.03	0.46	4.05
1948	1.98	0.30	0.06	0.20	0.69	0.01	0.02	0.66	3.92
1955	4.13	0.33	0.13	0.25	0.67	0.01	0.02	1.16	6.60
1961	2.04	0.35	0.46	1.23	0.78	0.03	0.04	1.71	6.64
1966	2.63	0.50	0.45	1.09	0.60	0.06	0.03	3.10	8.46
1971	3.19	0.30	0.48	1.44	0.78	0.06	0.01	7.20	13.46
1976	7.04	0.28	0.35	0.85	0.45	0.04	0.00	21.90	30.91
1978	12.57	0.19	0.41	1.11	0.24	0.01	0.00	22.42	36.95
1979	12.05	0.21	0.36	1.11	0.19	0.01	0.00	18.80	32.73
1980	10.54	0.15	0.29	1.02	0.10	0.01	0.00	10.68	22.79
1981	9.77	0.09	0.26	0.82	0.10	0.01	0.00	6.20	17.25
1982	9.57	0.04	0.33	0.74	0.08	0.01	0.00	5.14	15.91
1983	10.53	0.03	0.31	0.72	0.04	0.00	0.00	5.50	17.13
1984	11.84	0.03	0.35	0.71	0.04	0.00	0.01	5.60	18.58
1985	10.57	0.03	0.29	0.48	0.07	0.00	0.01	7.66	19.11
1986	9.14	0.03	0.15	0.26	0.09	0.00	0.01	4.29	13.97
1987	8.38	0.02	0.08	0.18	0.04	0.00	0.00	2.53	11.23
1988	8.96	0.01	0.10	0.20	0.01	0.00	0.00	2.80	12.08
1989	7.43	0.01	0.05	0.10	0.03	0.00	0.00	2.21	9.83
1990	7.51	0.01	0.07	0.14	0.09	0.00	0.00	2.07	9.89
1991	7.54	0.01	0.08	0.13	0.06	0.00	0.00	3.03	10.85

Table 5. Recorded fish catches in Lake Sevan in centners

Years	Ishkhan	White Fish	Koghak	Sevan Barbel	Crusian Carp	TOTAL
1926-1930	5113	25	3109	62	0	8310
1931-1935	5740	14	3438	147	0	9339
1936-1940	5779	22	5262	180	0	11243
1941-1945	3459	18	5349	89	0	8915
1946-1950	3050	94	5361	86	0	8591
1951-1955	4018	419	5583	204	0	10225
1956-1960	3000	1128	5096	179	0	9403
1961-1965	2636	2550	4333	67	0	9585
1966-1970	1758	5414	2712	50	0	9935
1971-1975	734	7615	1547	20	0	9915
1976-1980	100	9640	2763	0	0	12503
1981	8	11341	2668	0	0	14017
1982	10	9963	2714	0	0	12687
1983	8	10345	2678	0	0	13029
1984	0	16069	2096	0	0	18186
1985	0	13879	2565	0	4	16448
1986	0	14034	2447	0	14	16495
1987	0	16271	2399	0	87	18756
1988	0	17640	1592	0	27	19260
1989	0	18955	1911	0	225	21091
1990	0	19839	1104	0	516	21458
1991	0	17980	663	0	682	19325
1991-2003	?	?	?	?	?	?

Table 6. International reports of the Ministry of Nature Protection with wetland measures	
Reports to international treaties	Measures projected (O) and implemented (X) in the wetlands
<i>First National Communications of the Republic of Armenia under the UNFCCC</i> (Final National Report, 1998)	<i>Recognition of the role of Lake Sevan in climate mitigation and greenhouse gas effect reduction without special measures proposed</i>
<i>Armenia National Environmental Action Program</i> (Main Report, 1999)	O. Development of integrated water resources master plan X. Undertake pilot project for restoration of Lake Gilli (successful)
<i>Biodiversity of Armenia</i> (Final National Report, 1999)	<i>Special attention is given to conservation of wetland biodiversity and wetland landscapes, in particular in Lake Sevan Basin, without special measures particularly related to the wetlands</i>
<i>Biodiversity Strategy and Action Plan of Armenia</i> (Main Report, 1999)	O. Provide technical assistance and equipment to Sevan National Park O. Establish new protected areas X. Conserve and rehabilitate key wetland ecosystems, including ecosystem of Lake Sevan (unsuccessful) O. Develop individual action plan for conservation endangered fish Ishkhan X. Promote sustainable fisheries (extremely unsuccessful) X. Wetland management training (successful)
<i>Lake Sevan Action Program</i> (Main Report, 1999)	X. Undertake pilot project for restoration of Lake Gilli (successful) X. Rehabilitate Ishkhan hatcheries (extremely unsuccessful) X. Develop crayfish fishery (relatively successful) X. Collect environmental data (relatively successful)
<i>Natural Resources Management and Poverty Reduction Project</i> (ongoing)	<i>Gegharqouniq Marz is one of two case areas of project implementation. In particular, management plan for Sevan National Park should be prepared and implemented.</i>

Table 7. Lake Sevan Action Program - Phased Implementation Program	
PHASE I - US\$ 2,000,000	
Establishment of Lake Sevan Commission	US\$ 900,000
Policy Measures and Instruments and Legal Reforms	US\$ 400,000
Integrated Management Policy and Planning Activities	US\$ 700,000
PHASE II - US\$ 4,200,000	
Environmental Awareness	US\$ 500,000
Improving Water quality	US\$ 3,600,000
Biodiversity and the National Park	US\$ 100,000
PHASE III - US\$ 6,800,000	
Increasing Water Quantity	US\$ 1,500,000
Improving Water quality	US\$ 750,000
Biodiversity and the National Park	US\$ 900,000
Fisheries	US\$ 1,150,000
Applied Research	US\$ 2,500,000
PHASE IV - US\$ 17,000,000	
<i>Increasing Water Quantity (Vorotan, Eghvard)</i>	<i>(US\$ 115,000,000)</i>
Improving Water quality	US\$ 16,600,000
Biodiversity and the National Park	US\$ 400,000
TOTAL (without Vorotan Tunnel and Eghvard Reservoir) US\$ 30,000,000	