INTRODUCTION OF PAYMENT FOR ECOSYSTEM SERVICES SCHEMES IN UPPER HRAZDAN PILOT RIVER BASIN OF ARMENIA

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EXECUTIVE SUMMARY IN RUSSIAN

ВНЕДРЕНИЕ СХЕМ ПЛАТЫ ЗА УСЛУГ ЭКОСИСИТЕМ В ПИЛОТНОМ РЕЧНОМ БАССЕЙНЕ ВЕРХНЕГО ТЕЧЕНИЯ РЕКИ РАЗДАН АРМЕНИИ

РЕЗЮМЕ

В марте 2010г. в области КУВР в течение заседания руководительной группы диалога нациаональной политики было принято решение поддержать развитие рынка воды в Армении и стимулировать употребление финансовых инструментов в области управления водой, включая плату за услуги экосистем.

Было принято решение употреблять положения указания "Предложения в области управления водными ресурсами о плате за экосистемных услуг", которое было обработано странами ООН Европы, что даст возможность обработать новые финансовые механизмы для управления природными ресурсами Армении с учетом стоимости хозяйственных и экологических услуг (например, регулирование стока рек и др.).

Таким образом, осуществилась пилотная программа, целью которого была обработка пакета политики, которая послужит основой для уполномоченного органа управления водных ресурсов с целью проведения законодательных изменений в области ПЭУ. С этой целью осуществилась подробная исследовательская работа, результаты которого обобщаются ниже.

Для внедрения и применения систем платы за экологические услуги, согласно показателям указания ПЭУ, принятым экономической комиссией Европы ООН, было выбрано верхнее течение реки Раздан, находящейся в центральной части территории Армении, до села Кахси, включая притоки Мармарик и Цахкадзор. Площадь выбранного бассейна составляет 780 км^2. На этой территории живут 99.4 тысяч людей, 50,7% которого составляют женщины, а 49,3%-мужчины. Средняя плотность населения составляет 127 чел/км^2.

Первая глава отчета включает обзор литературы касающихся схем платы за экосистемные услуги. Детально исследуются рекомендацци касающиеся платы за услуги экосистем в контексте управления водными ресурсами, подготовленные секретаритом Конвенции по охране и исполцзованию трансграничных водотоков и международных озер Европейской экономической комиссией Организации Обьединенных Наций. **Вторая** глава представляет критерии по которым был выбран пилотный бассейн для внедрения схем платы за услуг экосистем.

Третья глава отчета подробно описывает состояние окружающей среды пилотного бассейна. Рельеф речного бассейна типично горный, климат - умеренный: лето теплая а зима холодная, средняя годовая температура воздуха колеблется в пределах 2.7-8,2 ^{0}C, общегодовые атмосферные осадки составляют 850мм, а суммарное испарение- 250-450мм. В бассейне преобладают горные степи, а лесные участки составляют 12,9% от общей площади территории.

Территория исследуемого бассейна принадлежит гидрографической сети реки Раздан. Самый крупный приток Раздана река Мармарик. В течнии года речной сток распределен неравномерно. Основная часть речного стока проходит во время весеннего половодья, а в течении лета и зимы намечаются маловодные периоды. За год через реку Раздан из исследуемой территории выходит около 244 млн. м^3 воды. Сток реки за год распределен наравномерно. Из природных опасных явлений наблюдаются селевые потоки (в основном нижные и средные течения р.Мармарик), береговая и пространственная эрозия слабо развиты, опользней немного. Лавины наблюдаются в основном в верхнем течении р.Цахкадзор.

Качество вод рек Раздан и Мармарик хорошее и удовлетворяют требованиям водопользования.. В городе Цахкадзор и ниже его, в нижнем течении реки Цахкадзор, вода подтвергается существенному человеческому давлению, в связи с чем качество воды плохое или очень плохое.

В четвертой главе отчета анализируется использование природных рессурсов бассейна, включая использование ландшафтов, землепользование, водозабор и сброс.

Самое существенное человеческое давление на ландшафты заметно в степях. Населенные пункты, промышленные предприятия, сельскохозяйственные угодья и другие хозяйственные объекты в основном распределены в этой зоне. Растительность алпийских и субалпийских лугов, как правило, деградируется в связи с неправилным методом пасти скота, незаконно открытыми автомобильными дорогами со стороны водителей, из-за отсутствия дорожных переходов дия скота, из-за небрежного сбора полевых цветов и лечебных трав и др.

Из-за энергетического кризиса в 1990-ые годы и в результате ухудшения социально-экономического уровня населения, леса исследуемого района из-за незаконной ее рубки оказали огромный вред хозяйсву. В лесах, близких к населенным местам также пасется скот, которое отрицательно влияет на условия выращивания леса, уничтожаются молодые деревья, семена и т.д.

В пилотной территоррии водопользование осуществляется в цельях бытового и промышленного водопотребления, гидроэнергетики и орошения. Для коммунально-бытового водоснабжения за год употребляется 43,3 млн.м^3 воды, для промышленного водоснабжения-12.2 млн м^3, в целях орошения - примерно 2,5 млн м^3 воды, а возвратные воды после использования составляют почти 34-44 % от общего количества водозабора.

Для орошения бассейна воду снабжает компания «Раздан Джур», общая территория обслуживания которого составляет примерно 9210 га. Годовая потеря воды из оросительных систем составляет 42%.

В пятой главе отчета осуществляется диагностический анализ качества и количества воды, степень водопользования, эрозионных процессов, рубки леса и деградации земель.

Качество воды в реках Раздан и Мармарик хорошая, и только воды реки Цахкадзор в последные годы имеют тенденцию ухудшения. Это обусловлено давлением коммунально-бытовых вод в районе территории города Цахкадзор, которая увеличивается из-за резкого роста числа туристов и домов отдыха, поскольку у большинства туристических центров не

имеются очистные станций и вода с этих территории, без очисти, сбрасывается в реку Цахкадзор.

В пилотном бассейне существует ряд проблем, связанных с нехваткой воды, которая больше всего заметна в летнем сезоне. В добавление к этому, из-за влияния изменений климата, по прогнозным данным можно предвидеть уменьшение водных ресурсов на 5-24% в 2030-2100 гг, что в свою очередь обострит дифицит водопотребления.

В каждый год, особенно в периоды весенных половодий, на реках Раздан и Мармарик наблюдаются береговая эрозия и наводнение берегов, которые причиняют огромный вред сельскому хозяйству.

На территории бассейна в последные два десятилетия было вырублено примерно 180-200 га лесов. Незаконная рубка лесов продолжается и по сей день.Кроме того площади лесов уменьшаются также за счет расширения территорий гостиниц и ресторанов (в речных бассейнах Цахкадзор и Мармарик).

В четвертой главе отчета рассматривается правовое поле применения хозяйственных инструментов в целях решения выявленных задач. В рамках этого поля обсуждения показывается, что водный кодекс Армении дает возможность обработать в контексте КУВР механизмы и предложения для реализации схем ПЭУ. 11-ая глава кодекса относится к системе экономических стимулов и плат, 76-ая статья которого определяет принципы использования, восстановления и охраны водных ресурсов, а также принципы урегулирования систем водоснабжения и водоотведения. 77-ая статья той же главы определяет основы платы разрешения водопользования, которые после принятия кодекса применяется не целиком.

В шестой главе анализируются также вопросы применения природоохранных плат для водопользования указанных и в других кодексах РА (земельных, о недрах, лесной), и в законах урегулирования правового взаимоотношения природопользователей.

В седьмой главе предлагается схема ПЭУ пилотного бассейна. Согласно решению правительства РА от 14 августа 2003 г. N1110 Н “Об установлении порядка оценки влияния хозяйстженной деятельности на водные ресурсы, рассчитан экономический ущерб, нанесенный реке Цахкадзор в зимне-летные месяцы, выраженный в БПК, в случае внезапного сброса загрязненных вод. Получено, что зимне-летные месяцы сбрасывается около 113 т БПК, которое речным водам наносит ущерб в размере около 28 тыс. доллара. Предполагается, что при учете количества и других вредных веществ в воде, экономический ущерб увеличится почти на 2-3 раза.

Учитывая приказа министра охраны природы РА “ Методика расчета величины допустимого предельного сброса неочищенных вод в водные ресурсы”, расчитана величина БПК для реки Цахкадзор, которая составляет 7.24 мг/л. То-есть, река Цахкадзор в данном участке сброса канализационных вод имеет такую величину самоочищения, что влияние на речную воду от точки слияния до 500 м вниз по течению БПК воды уменьшается до допустимого предела.

Исходя из вышеизложенного, в пятой главе отчета предлагается также пределы применения ПЭУ и ставка. Так-как канализационная вода имеющая органическую загрязненность с концентрацией более 7.24 г/м^3 не поддается к самоочищению и оказывает отрицательное влияние на эту экосистему, то в таких случаях необходимо применять более высокую ставку платы за услуг экосистемы. Для определения ставку ПЭУ предлагается применять принятий в водном кодексе РА принципа, что загрязнитель платит, а величина оплаты за загрязнение должна удовлетворять требуемого финансового объема осуществляющих мероприятий по предотвращению и устранению загрязнения.

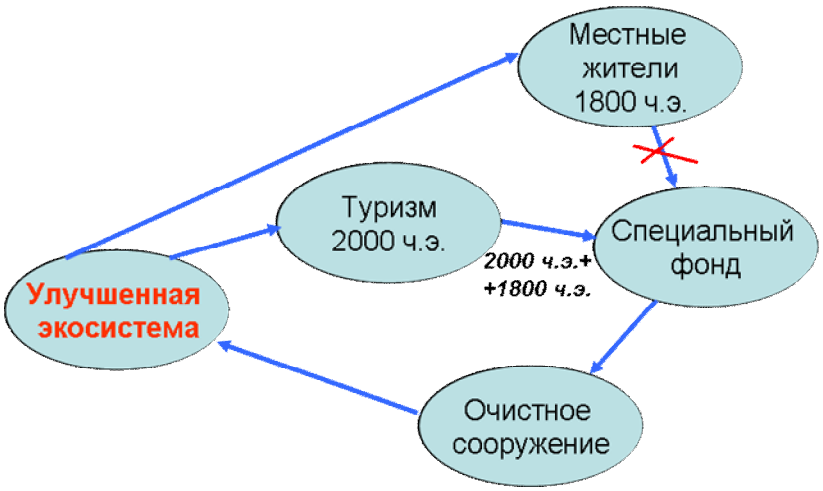
Число населения, оказывающее человеческое давление на реку Цахкадзор составляет 3,800 человек, из которой 1800 постоянное население, а 2,000- временое (дома отдыха, спорт базы, объекты общественного питания и др.). Согласно предварительным оценкам для строительства очистной станций в городе Цахкадзор, требуется около 250 тыс евро. Исходя из идеологии ПЭУ логично, что единица ставки (по части БПК) должно определятся по величине финансовых расходов (250 тыс евро) и диапазоне применения ПЭУ-232.76 г/м3 (240-7.24) загрязненная в течении летне-зимнего сезона 0.030 м3/с БПК по отношению:

$$ПЭУ_{ставка} = \frac{5000 \text{ евро}}{232.7 \text{ г/м}^3 \times 0.30 \text{ м}^3/\text{с} \times (180 \times 86.400)}$$

где 180 x 86400 - число секунд за промежуток вевмени лето-зима = 15.552 млн.

$$ПЭУ_{ставка} = \frac{5000}{108568512} = 0{,}000046 \text{ евро/грамм.}$$

Таким образом, ПЭУставка для объектов, действующих на пребрежной территории реки Цахкадзор, равно 0,000046 евро для 1г БПК сброса в реку. То есть, предлагается применять его по отношению 2000 временных посетителей в пользу экосистемы и 1800 постоянных жителей, для этой цели, создавая специальный фонд, находящийся под управлением населения Цахкадзор, средства которых должны употреблятся на финансирование мероприятий, направленных на уменьшение загрязнения реки Цахкадзор.



В последней главе отчета также представляются следующие шаги, которые предлагаются примененият в принципах ПЭУ, выполнять соответственные изменения и дополнения в действующих законопроектах республики.

Предлагается принять закон РА “О платах за экосистемных услуг” с помощью которого будет определятся предмет урегулирования закона, основные понятия, плателщики ПЭУ, виды ПЭУ, ставки, порядок учета и платежа, порядок учета фактических объемов объектов ПЭУ и др.

В настоящей главе представляются также какие изменения и дополнения нужно принять и в других законах РА, связанных с законом РА «О платах экосистемных услуг».

1. LITERATURE REVIEW

1.1. Documents Studied

In the course of review of available publications on PES approaches and best practices the following background materials were studied:

- Branko Bosnjakovic, "Valuation and Payment Mechanisms for Ecosystem Services in Integrated Water Resources Management", prepared within the project "Principles for Multipurpose Management in Sava River Basin", November, 2006.
- Franciso Alpizar, Allen Blackman and Alexander Pfaff, "Payments for Ecosystem Services: Why Precision and Targeting Matter", 2007.
- "International Payments for Ecosystem Services", A global research initiative sponsored by United Nations Environmental Program, International Union for Conservation of Nature in close cooperation with the Convention on Biological Diversity, 2008.
- James Boyd and Spencer Banzhaf, What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units. Resources for the Future Discussion Paper, available at: http: //www.rff.org/Documents/RFF-DP-06-02.pdf
- James Mayers, Charles Batchelor, Ivan Bond, Rob Hope, Elaine Morrison and Breana Wheeler, "Water Ecosystem Services and Poverty under Climate Change: Key Issues and Research Priorities", 2009.
- Julia Wesely, "Policy Outcomes on Water-Related Ecosystem Services in an Agricultural Landscape in South Africa", 2010.
- Living beyond Our Means; Statement from the board of the Millennium Ecosystem Assessment, available at http: //www.millenniumassessment.org/documents/document.429.aspx.pdf.
- Matt Jenkins, Mother Nature's Sum. Miller-McCune Online Article, available at: http: //www.miller-mccune.com/article/677
- Millennium Ecosystem Assessment, "Ecosystems and Human Well-Being", 2003.
- Millennium Ecosystem Assessment, "Ecosystems and Human Well-Being: Wetlands and Water Synthesis", 2005.
- Pablo Gutman, "Payment for Ecosystem Services: A WWF Perspective", a presentation at the workshop on: Conservation Finance Global Biodiversity Forum, Brazil, 2006.
- Paying Farmers for Environmental Services (Opening pages). United Nations Food and Agriculture Office Report. Available at: ftp: //ftp.fao.org/docrep/fao/010/a1200e/a1312e00.pdf
- Robert Costanza et al. The value of the world's ecosystem services and natural capital. http: //www.nature.com/nature/journal/v387/n6630/pdf/387253a0.pdf
- Thomas Greiber, "Payments for Ecosystem Services: Legal and Institutional Frameworks", IUCN Environmental Policy and Law Paper No. 78, 2010
- UN ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, "Recommendations on Payments for Ecosystem Services in Integrated Water Resources Management", 2007.
- UNEP Ecosystem Management Programme, "Water Security and Ecosystem Services: The Critical Connection", 2009
- Wilson, M.A., and Howarth, R.B., "Discourse-based Valuation of Ecosystem Services: Establishing Fair Outcomes through Group Deliberation", 2002.
- Wouter H. Maes, Griet Heuvelmans and Bart Muys, "Assessment of Land Use Impact on Water-Related Ecosystem Services Capturing the Integrated Terrestrial-Aquatic System", 2009.

These materials provided background information on the range of definitions of the terms "ecosystem services" and "payments for ecosystem services", the categories and scales of PES services, types of PES schemes, as well as examples of PES programs which procure some sort of water-related ecosystem service.

1.2. Definitions

Payments for Ecosystem Services (PES), also known as **Payments for Environmental Services (or Benefits)** broadly defined, is the practice of offering incentives to farmers or landowners in exchange for managing their land to provide some sort of ecological service.

Ecosystem services have no standardized definition, but might broadly be called "the benefits of nature to households, communities, and economies"[1] or, more simply, "the good things nature does"[2]. According to the Millennium Ecosystem Assessment[3] the ecosystem services are "benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits".

According to UN ECE "Ecosystem services" means the benefits people obtain from ecosystems[4]. These include provisioning services such as food, water, timber and fibber; regulating services that affect climate, floods, disease, wastes and water quality; cultural services that provide recreational, aesthetic and spiritual benefits; and supporting services such as soil formation, photosynthesis and nutrient cycling.

Similarly, there are numerous definitions for the term payment for ecosystem services. For the purposes of this report "Payments for ecosystem services (PES)" means a contractual transaction between a buyer and a seller for an ecosystem service or a land use/management practice likely to secure that service. The term "payments for ecosystem services" is not universally adopted. Depending on the cultural and political context, other terms such as "recompense", "compensation" or "reward" may be used. PES projects are also referred to as "improved management of hydrological resources" or "reciprocal arrangements". PES is sometimes called "incentive-based cooperative agreements", "stewardship payments", "compensatory schemes" or even "performance payments".

PES programs are voluntary and mutually beneficial contracts between consumers of ecosystem services and the suppliers of these services. The party supplying the environmental services holds the property right over an environmental good that provides a flow of benefits to the demanding party in return for compensation. The beneficiaries of the ecosystem services are willing to pay a price that is lower than their welfare gain due to the services. The providers of the ecosystem services are willing to accept a payment that is greater than the cost of providing the services.

1.3. Categories of PES Services and Types of PES Schemes

Twenty-four specific ecosystem services were identified and assessed by the Millennium Ecosystem Assessment, a 2005 UN-sponsored report designed to assess the state of the world's ecosystems. The report defined the broad categories of ecosystem services as ***food production*** (in the form of crops, livestock, capture fisheries, aquaculture and wild foods), ***fibre*** (in the form of timber, cotton, hemp, and silk), ***generic resources*** (bio-chemicals, natural medicines, and pharmaceuticals), ***fresh water***, air quality regulation, climate regulation, ***water regulation***, erosion

[1]) James Boyd and Spencer Banzhaf, What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units. Resources for the Future Discussion Paper, available at: http://www.rff.org/Documents/RFF-DP-06-02.pdf
[2]) Matt Jenkins, Mother Nature's Sum. Miller-McCune Online Article, available at: http://www.miller-mccune.com/article/677
[3]) Millennium Ecosystem Assessment, "Ecosystems and Human Well-Being: Wetlands and Water Synthesis", 2005.
[4]) UN ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, "Recommendations on Payments for Ecosystem Services in Integrated Water Resources Management", 2007.

regulation, water purification and waste treatment, disease regulation, pest regulation, pollination, natural hazard regulation, and ***cultural services*** (including spiritual, religious, and aesthetic values, recreation and ecotourism)[5].

However, there is a "big three" among these 24 services which are currently receiving the most money and interest worldwide. These are climate change mitigation, watershed services and biodiversity conservation.

Ecosystem services may be present at any scale: local, national and international. An example of service at local scale includes water quality benefits of conservation in a small watershed. The country-wide benefits of biodiversity conservation are an example of national scale service. And finally, global common benefits of conserving biodiversity, international waters or the atmosphere are example of ecosystem service at international scale.

The general classification of PES distinguishes the following major types of PES schemes[6]: public schemes, private (self-organized) schemes and trading schemes. The type of buyers, i.e. States, public/private utilities, business or others, will influence the type of PES and the type of financial arrangements.

Public schemes are schemes in which a municipality or a local or national government acts as the sole or primary purchaser of a specified ecosystem service or, more commonly, a related land use or management practice. Public schemes may operate at the local or national level.

In private (self-organized) schemes, both buyers and sellers are private entities (companies, NGOs, farmers' associations or cooperatives, private individuals). Private self-organized schemes are typically local schemes. Trading schemes refer to the establishment of markets in which established rights (or permits) and/or quotas can be exchanged, sold or leased. The existence of a strong, well-defined and functioning legal and regulatory framework is a prerequisite for trading schemes to operate.

Public and private PES schemes may adopt different financial arrangements regarding the compensation to sellers and the collection of buyers' contributions. The six most common financial arrangements include (for sellers) direct compensation, investment or development funds, and land purchasing and (for buyers) customer-charged payments, lump-sum contributions and tax-based contributions.

1.4. Valuation of Ecosystem Services

Ecosystem values are measures of how important ecosystem services are to people – what they are worth. Economists measure the value of ecosystem services to people by estimating the amount people are willing to pay to preserve or enhance the services. However, this is not always straightforward, for a variety of reasons.

Most importantly, while some services of ecosystems, like fish or lumber, are bought and sold in markets, many ecosystem services, like a day of wildlife viewing or a view of the ocean, are not traded in markets. Thus, people do not pay directly for many ecosystem services. Additionally, because people are not familiar with purchasing such goods, their willingness to pay may not be clearly defined. However, this does not mean that ecosystems or their services have no value, or cannot be valued in dollar terms.

[5]) Living Beyond Our Means; Statement from the board of the Millennium Ecosystem Assessment, available at http://www.millenniumassessment.org/documents/document.429.aspx.pdf.
[6]) UN ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, "Recommendations on Payments for Ecosystem Services in Integrated Water Resources Management", 2007.

It is not necessary for ecosystem services to be bought and sold in markets in order to measure their value in dollars. What is required is a measure of how much purchasing power (dollars) people are willing to give up to get the service of the ecosystem, or how much people would need to be paid in order to give it up, if they were asked to make a choice similar to one they would make in a market.

Economists classify ecosystem values into several types. The two main categories are ***use values*** and ***non-use***, or "passive use" values[7]. Whereas use values are based on actual use of the environment, non-use values are values that are not associated with actual use, or even an option to use, an ecosystem or its services.

Thus, use value is defined as the value derived from the actual use of a good or service, such as hunting, fishing, bird watching, or hiking. Use values may also include *indirect uses*. For example, an Alaskan wilderness area provides direct use values to the people who visit the area. Other people might enjoy watching a television show about the area and its wildlife, thus receiving indirect use values. People may also receive indirect use values from an input that helps to produce something else that people use directly. For example, the lower organisms on the aquatic food chain provide indirect use values to recreational anglers who catch the fish that eat them.

Option value is the value that people place on having the option to enjoy something in the future, although they may not currently use it. Thus, it is a type of use value. For example, a person may hope to visit the Alaskan wilderness area sometime in the future, and thus would be willing to pay something to preserve the area in order to maintain that option.

Similarly, *bequest* value is the value that people place on knowing that future generations will have the option to enjoy something. Thus, bequest value is measured by peoples' willingness to pay to preserve the natural environment for future generations. For example, a person may be willing to pay to protect the Alaskan wilderness area so that future generations will have the opportunity to enjoy it.

Non-use values, also referred to as "passive use" values, are values that are not associated with actual use, or even the option to use a good or service. Existence value is the non-use value that people place on simply knowing that something exists, even if they will never see it or use it. For example, a person might be willing to pay to protect the Alaskan wilderness area, even though he or she never expects or even wants to go there, but simply because he or she values the fact that it exists.

It is clear that a single person may benefit in more than one way from the same ecosystem. Thus, total economic value is the sum of all the relevant use and non-use values for a good or service.

1.5. Process in PES Establishment

The schemes for payments for ecosystem services can be designed and introduced in a context, where there are already well-defined and measurable links between a certain activities or conservation practice and the quantity and quality of ecosystem services. "Recommendation on Payments for Ecosystem Services in Integrated Water Resources Management"[8] presents a flow chart illustrating some questions to be answered and analysis to be carried out before deciding on establishment of a PES scheme. Thus, the chart below presents a set of questions that have to be addressed and analysis that have to be undertaken in the process of deciding whether the establishment of a PES scheme is feasible and useful.

[7]) http://www.ecosystemvaluation.org
[8]) UN ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, "Recommendations on Payments for Ecosystem Services in Integrated Water Resources Management", 2007.

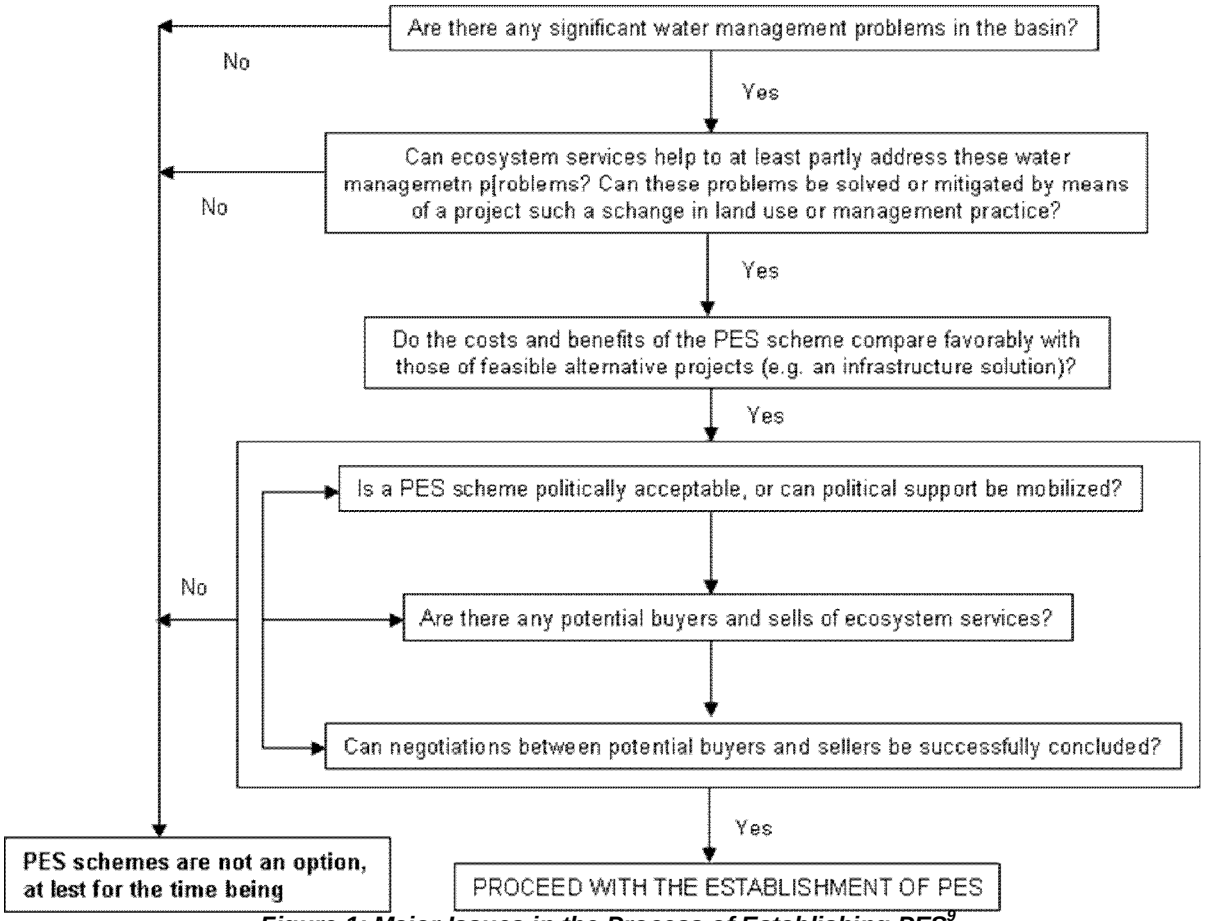


Figure 1: Major Issues in the Process of Establishing PES[9]

1.6. Examples

Table below provides examples of various payments for ecosystem services.

Table 1: Examples of local, national and international level public and private PES schemes

Water related ecosystem service	Description	Buyer	Seller
Improvement of water quality, control of soil erosion and enhancement of habitats for waterfowl and wildlife	The world's largest and longest running PES program is the United States' Conservation Reserve Program,[10] which currently pays about $1.8 billion a year under 766,000 individual contracts with farmers and landowners to "rent" a total 34,700,000 acres (140,000 km^2) of what it considers "environmentally-sensitive land.[11]„ These farmers agree to plant "long-term, resource-conserving covers to improve water quality, control soil erosion and enhance habitats for waterfowl and wildlife."	United States' Conservation Reserve Program	Farmers and landowners
Erosion reduction, saving the streams and	In 2000, the Chinese central government announced an expensive project under its $43 billion Grains for Green program, by which it offers farmers grain in exchange for not clearing forested slopes for farming, thereby reducing	Central Government of China	Farmers

[9]) UN ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, "Recommendations on Payments for Ecosystem Services in Integrated Water Resources Management", 2007.
[10]) Matt Jenkins, Mother Nature's Sum. Miller-McCune Online Article, hereinafter Jenkins
[11]) United States Department of Agriculture news release: USDA Issues $1.8 Billion in Conservation Reserve Payments.

Water related ecosystem service	Description	Buyer	Seller
rivers	erosion and saving the streams and rivers below from the associated deluge of sedimentation.		
Provision of clean water	Cumes River is the town's main source of clean water for the town Jesus de Otoro, Hondurs. Coffee producers were dumping their waste into the river upstream, polluting the source and directly affecting the consumers downstream. To solve this problem, the local Council for Administration of Water and Sewage Disposal (JAPOE) created a payment program to benefit coffee producers upstream and the town's inhabitants that lived downstream. The villagers downstream paid around $0.06 per household per month to JAPOE. JAPOE redirected the money towards upstream farmers. The farmers complied with various guidelines, such as construction of irrigation ditches, proper management of waste, and use of organic fertilizers.	The villagers downstream	Upstream farmers
Provision of high-quality mineral drinking water	Nestlé, which owns the natural mineral water sources of Vittel in north-eastern France, protected the spring catchment area, which was intensively farmed (with resulting nutrient run-off and pesticide residues), by purchasing agricultural land and reforesting it. It also reduced further non-point pollution by signing 18-to-30-year contracts with the local farmers to reduce nitrate pollution by adopting extensive and optimal cattle-ranching practices and replacing corn crops with alfalfa. The yearly payments are based on the opportunity cost and the actual costs of technological change. Vittel financed investment costs and paid US$ 230 per hectare and per year for a period of seven years to cover the reduced profitability.	Nestlé Waters, which owns the natural mineral water sources of Vittel S.A. in north-eastern France	Dairy farmers
Improving the quality of surface waters and groundwater	Change of management practice in agriculture. Examples of commitments covered by agro-environmental schemes: (a) environmentally favourable extensification of farming; (b) management of low-intensity pasture systems; (c) integrated farm management and organic farming; (d) preservation of landscape and historical features such as hedgerows, ditches and woods; and (e) conservation of high-value habitats and their associated biodiversity. Farmers receive payments that compensate for additional costs and loss of income that arises as a result of altered farming practices. The average agro-environmental payment is € 89 per hectare and year, and for organic farming € 186 per hectare and year.	EU government authorities	Farmers
Reduction of nitrate charges in groundwater and consequently of nitrate input into the North Sea via the river Rhine; provision of high-quality drinking water	In Switzerland, precipitation generates drinking water to the value of about € 3,500 per hectare of agricultural land. As intensive farming not adapted to local conditions is the main cause of groundwater nitrate pollution, further measures were needed in addition to strong legislation on water protection and agriculture; these include voluntary programs promoting extensification. The objective of the PES scheme was to change management practice in order to decrease nitrate pollution in groundwater, with an emphasis on groundwater used for drinking water. Compensation varied from € 130 per hectare and year for measures in open cultures to € 1,250 for enhancing the meadow's surface.	Federal Government of Switzerland, cantons and water supplier	Farmers
Provision of high-quality drinking	The New York City–Catskill watershed management program is a striking example of a public payment scheme. The Catskill and Delaware watersheds provide 90 per cent	NYC municipal water-supply	Upstream forestry landowners,

Water related ecosystem service	Description	Buyer	Seller
water for New York City (NYC) through natural filtration rather than construction of a new filtration plant	of the water consumed by the city of New York. As the quality of water decreased in the 1990s, the United States Environmental Protection Agency (EPA) required that all surface water be filtered, unless safe water could be provided under natural conditions. It was estimated that building a filtration plant would cost US$ 6 billion to 8 billion and its yearly operation US$ 300 million to 500 million. Instead of building a filtration plant, the city authorities decided to invest US$ 1.5 billion over 10 years in a watershed program to be administered by the Catskill Watershed Corporation, a non-profit organization. The program is based on improvements in farm and forestry practices in order to reduce water pollution. The PES scheme was initiated with money from the city of New York, the state of New York and the Federal Government. Now the scheme is financed by a tax included in New York water users' bills. Dairy farmers and foresters adopting good management practices were compensated with US$ 40 million, which vowed their additional costs. Foresters who improved their management practices (e.g. by using low-impact logging) received additional logging permits for new areas. Forest landowners owning 50 acres or more and agreeing to commit to a 10-year forest management plan were entitled to an 80% reduction in local property taxes.	company	farmers and timber companies

2. SELECTION OF PILOT RIVER BASIN

For introduction and application of the system of payment for ecosystem services in Armenia first criteria for selection of river basin are developed taking into consideration PES guidelines developed by UNECE. Based on these criteria we have studied and selected pilot river basin - upper basin of Hrazdan River up to settlement Qaghsi, including right tributaries Marmarik and Tsaghkadzor (Figures 2 and 3).

2.1. Principles of selecting river basin

1. According to river basin area and average weighted altitude the average altitude and area of the selected river basin shall be characteristics for the country average,
- The area of the selected river basin is 774 km^2, and the average weighted altitude is 2170 m,

2. Characteristic geological structure and topography,
- In the selected river basin the geology includes structures of folded-mountain and volcanic origin,

3. Existence of different ecosystems and landscapes, and existence of forests,
- In the selected basin steppe landscape is dominant, about 9.3% is forest ecosystem, the basin also includes sub-alpine and alpine landscapes,

4. Population number,
- The selected river basin includes about 101,800 inhabitants, of which urban population is 75% and rural population is 25%,

5. Existence of industry,
- The selected basin includes mining and cement industry, thermal and power plant and food industry,

6. Existence of agriculture,
- The selected river basin includes livestock breeding, corn production and other crop production,

7. Existence of land use,
- The selected river basin includes irrigated and non-irrigated arable lands (around 10% of total), gardens, grasslands and pastures,

8. Multi-purpose water use,
- The selected river basin includes water use for industrial, drinking-household, energy, recreation, irrigation and other purposes,

9. Existence of water transfer from other basin (from Lake Sevan through Hrazdan River),

10. Existence of various water objects in the basin, including reservoir, canal, and other hydro-technical structures,

11. Existence of water supply and wastewater treatment facilities,

12. Existence of hydro-meteorological quantity and quality monitoring points,

13. Existence of recreational zones,
- The selected river basin includes numerous health resorts, summer and winter sport complexes, resort houses, mineral and freshwater springs,

14. Existence of reserves and reservations,

- The selected basin includes water and forest reserves,

15. Frequency of hydrological and hydro-geological hazards,

- In the selected basin the territories are frequently flooded, and mudflows, landslides, heavy winds and other hydro-meteorological events are frequent.

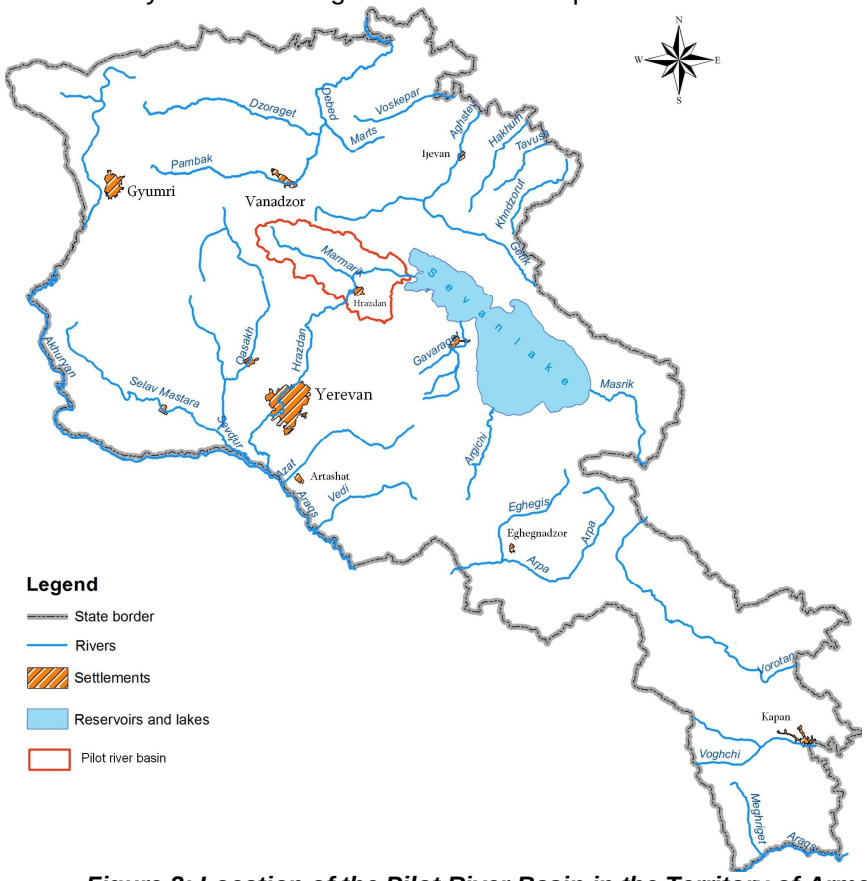


Figure 2: Location of the Pilot River Basin in the Territory of Armenia

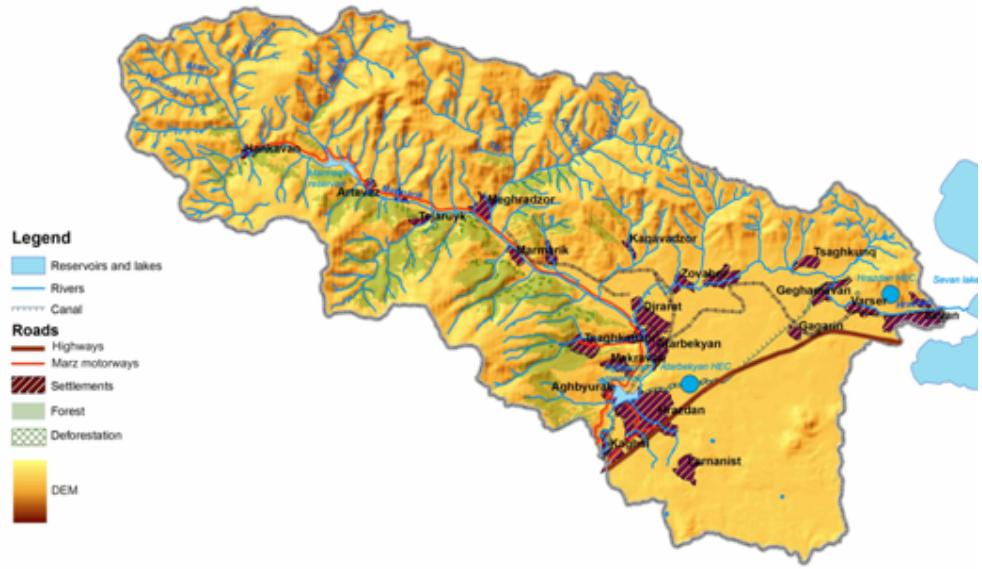


Figure 3: Map of the Territory of the Pilot River Basin

3. CHARACTERIZATION OF THE ENVIRONMENT

3.1. Geographic location

The selected pilot basin starts from the sources of Hrazdan River, which is the Lake Sevan and reaches until the settlement Qaghsi. The basin contains the basins of Marmarik and Tsaghkadzor tributaries.

The territory includes the upper sections of Hrazdan River, which involves the sections from two marzes (regions) of Armenia: Gegharkunik and Kotayq. From Gegharkunik marz the communities Sevan, Geghamavan, Varser, Ddmashen, Zovaber and Tsaghkunq are included. From Kotayq marz the communities Hrazdan, Tsaghkadzor, Aghavnadzor, Artavaz, Lernanist, Hanqavan, Meghradzor, Jrarat and Qaghsi are included.

The watershed of upper flows of Hrazdan River is located between the inter-mountainous gorge Tsaghkunyantz and Pambak. On the other side it occupies comparatively large gorge of upper Hrazdan, which on the left side joins with the western slopes of Geghama mountain range.

3.2. Topography

The topography is typical mountainous, where one can observe valleys, canyons and gorges segregated highly partitioned by Hrazdan River tributaries.

Pambak and the south-eastern Tsaghkunyatz mountain ranges have erosion-denudation surface and structurally partitioned topography. As for Geghama volcanic mountain range, until the altitude of 2500 m it is characterized with partially ledged topography, and mounds.

On the right banks of Hrazdan River water-resistant rocks are dominating. Contrary to that, on the left banks of the river highly porous and cracked water absorbing volcanic rocks of Jura's period are dominating.

From geomorphological perspective in the studied territory of Hrazdan River basin high mountainous and inter-mountainous zones are distinguished.

High mountainous zone is distributed over the south-western slopes of the Geghama mountain range, where the volcanic cones are widely distributed and which have an altitude of 2500-3500 m. Often highly maintained mixtures can be observed, which compose small lakes. On the surface the remnants of andesite-basalts lavas are dominating, the capacity of which reaches 20-30 m at certain places.

The inter-mountainous zone includes the zone of Geghama mountain range located between the altitude 1500-2500 m, which is characterized with regular undalatory, and partially ledged topography. It is covered with lava flow composed of andesite-basalt structures. River valleys have the form of V-shape.

3.3. Climate

The territory of the pilot river basin different climate zones: from mild zones (warm summer and cold winters) up to cold, mountainous zones (in Pambak and Geghama high mountainous zones). In the upper Hrazdan River basin the average annual air temperature varies from 8.2^0C at the altitudes 1600-1700 m above the sea level down to 2.7^0C at the altitudes of 2800 m and above. The total average annual quantity of precipitation composes 550-600 mm at the altitudes 1600-

1700 m up to 850-900 mm at the altitudes of 2800 m and above, and the total annual evaporation composes correspondingly 400–450 mm and 200 -250 mm.

Throughout the year the dominant direction of the wind is western and south-western, reaching 60% and the average speed of the wind is 0.9 m/sec. The number of days with thunder on average composes 39 days with the maximum of 74 days annually. The number of days with hails throughout the day is on average 5, and the maximum has is 24 days. The heating season ($\leq 8^0$C) starts from early October and lasts until the first decade of May.

The height of the snow cover (cm) in the first decade of December composes 15-30 cm, and reaches its maximum height in the second decade of March - 70-100 cm. The number of days with snow cover on average composes 140, with maximum being 180 days and minimum of 110 days. A stable snow cover is observed in the period between December-March.

Parallel to increase of altitudes above the sea level, the types of vertical climatic zones change in line with the increase of atmospheric precipitation and decrease of evaporation and temperature.

3.4. Landscapes

The following types of landscapes are distributed in the territory of the upper Hrazdan River basin: high mountainous alpine landscapes - 2,800-3,100 m, mountainous-steppes - 400-2,800 m, mountainous steppes - 1,600-2,400 m and forests - 1750-2250 m. The dominating landscape in the river basin is the mountainous steppes, which compose about 66.9% of the territory of the basin or 52,150 ha. High mountainous alpine landscape composes about 7.4% of the territory of the basin or 5,785 ha, and high mountainous sub-alpine landscape composes about 12.9% of the territory of the basin or 10,031 ha. The territories covered by forest compose about 12.9% of the entire territory of the basin or 10,034 ha (Figure 4).

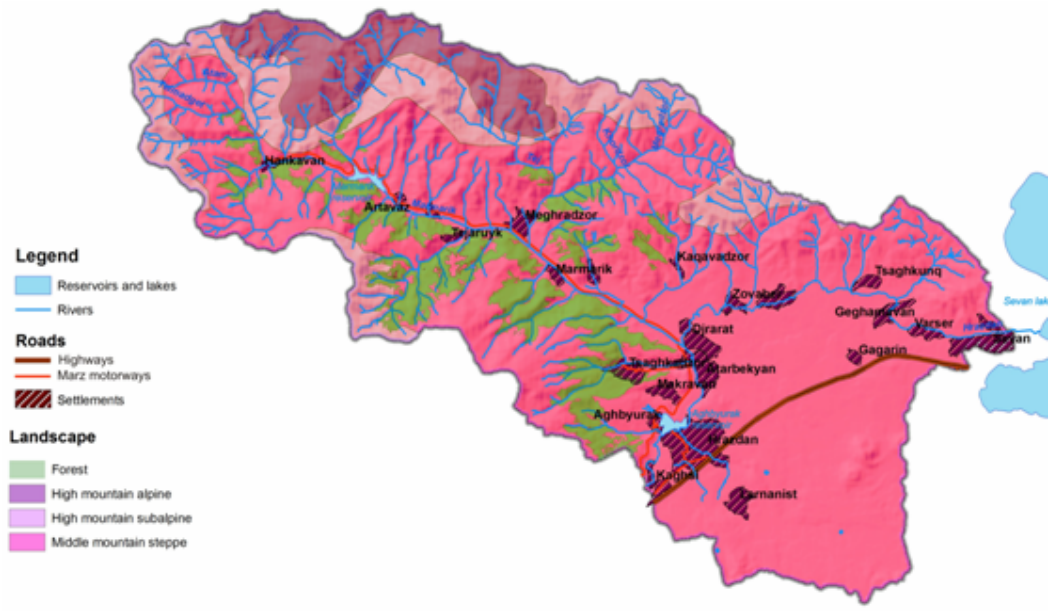


Figure 4: Landscapes of the Pilot River Basin

In alpine meadows the following types of plants are dominating: *Minuartia aizoides*, *Veronica kurdica*, *Taraxacum steveni*, *Potentilla agaea*, *Sibbaldia procumbens*, *Chamaesciadium acaule*. The sub-alpine meadows are drier and full of step-type of plans, including *Pyretrum szovittsii*, *P. balsamita*, *Antyllis boissieri*, *Helichrysum plicatum* and other.

The forests in the pilot river basin are under the state ownership. These state forests are managed by the Hrazdan branch of "Hayantar" (ArmForest) State Non-Commercial Organization (SNCO) under the Ministry of Agriculture, which includes the Meghradzor and Tsaghkadzor forest economies (Table 2). These forests are also included in the cadastral boundaries of the relevant communities.

Table 2: Forests in the pilot river basin

Forest economy	Total area, ha	of which, covered with forest, ha
Tsaghkadzor	9647	6727
Meghradzor	4792	3307
Total	***14439****	***10034****

*according to data from "Hayantar" SNCO

The conditions of forest growth are mesophilous mountainous. From the tree types the following are dominating: Caucasian hornbeam, Caucasian oak and Broad-leaved oak.

Broad-leaved forests with dominating type *Quercus iberica* of Georgian oak and abound sub-forests are distributed at the altitudes of 1600-2200 m. Sparse sub-forests and forests with dominating type *Carpinus caucasica* of Caucasian horn beam are distributed at the altitudes 1600-2000 m, and grass-covered forests with dominating type *Q. Macranthera* of broad-leaved oak are distributed at the altitudes of 1900-2400 m.

In the mountainous steppes cereals are dominating. They are mainly used as pastures. In the steppe territories located nearby of the settlements arable lands, and perennial plantations are dominating.

3.5. Soils

The soils in the river basin are mainly of the following types: mountainous brown, mountainous black, mountainous meadow-steppe and mountainous meadow.

In the lower reaches of Marmarik River grey meadow soils are distributed along the river, which fall under the irrigated areas. Mountainous brown soils are distributed in the territories of forests and steppe territories of the Marmarik River basin. Meadow-steppe type soils are distributed at the altitudes of 1800-2400 m of the Marmarik River basin. From Hrazdan city until Sevan city steppe black soils are dominating.

3.6. Hydrology

Hrazdan River originates from the largest lake in the region, Lake Sevan, at about 1900 m above the sea level. Due to artificial decrease of Lake Sevan level the bed of the Hrazdan River has become an artificially dug canal, as groundwater canal for Lake Sevan and derivation canal Atarbekyan hydropower station. In Sevan city the canal flows into a 5 km long underground tunnel and in Geghamavan village flows into the surface passing almost parallel to Yerevan-Sevan highway. Afterwards, it flows into Atarbekyan HPP, and then immediately flows into the Aghbyurak regulatory reservoir. From the old river bed of Hrazdan River currently annually only 50-80 l/second water flows, which is formed from the tributaries located in the eastern slopes of Pambak mountain range, as well as wastewater discharges from Sevan city and Tsaghkunq, Varser, Geghamavan, Ddmashen and Zovaber settlements. Near the settlement Jrarat right tributaries Marmarik and Tsaghkadzor confluence with Hrazdan River. Flowing out of Hrazdan city the river flows into the Aghbyurak reservoir, below which it flows through Qaghsi wastewater treatment station, which is currently inoperational and completely degraded (Figure 5).

The largest tributary to Hrazdan River in the pilot river basin is Marmarik River. Its length is 37 km and the watershed area is 427 km^2. Marmarik River originates from the north-western slope of

Tsaghkunyatz mountain range, at the altitude of 2520 m. It merges with Hrazdan River at 116 km from the Hrazdan River mouth. The overall direction of the river flow is south-eastern. Among the largest tributaries are Gomur, Yerkarget and Ulashik.

In the table 3 below the main morphological characteristics of Hrazdan River and its main tributaries are presented.

Table 3: Morphological characteristics of Hrazdan River and its upper sections

River name	Discharged to river	Distance from the river mouth, km	Altitude of the source, m	Altitude of the river mouth, m	Area of the basin, km^2	Length, km	Average incline, ‰
Hrazdan[12]	Araks	105	1900	1650	780	36	23
Marmarik	Hrazdan	116	2520	1699	427	37	22
Miskhana	Marmarik	30	2740	1951	40.5	11	72
Yerkarget	Miskhana	2.0	2890	2004	25.2	10	89
Ulashik	Marmarik	24	2791	1854	39.8	12	78
Shumlar	Marmarik	23	2550	1864	2.5	4	172
Artavaz	Marmarik	21	2465	1831	9.0	7	91
Kabakhlu	Marmarik	17	2570	1780	29.9	10	79
Gomour	Marmarik	12	2680	1755	104	15	62
Tsaghkadzor	Hrazdan	115	2820	1697	25.4	12	-

The hydrological observations in the upper Hrazdan River basin were initiated since 1913 (hydrological observation post city Hrazdan-post Sevan), however, the main observation works were implemented during the Soviet Union by the ArmStateHydroemt. In total 15 hydrological observation posts has been operation, of which 9 were located directly on Hrazdan River (it should be noted that due to various reasons the location of the most of theses post has been frequently changed). The majority of the posts have been closed in different years. Currently in the basin there are only 6 operational hydrological observation posts, 3 on Hrazdan River and 3 on Marmarik River (Table 4).

[12]) Hrazdan River until the settlement Qaghsi.

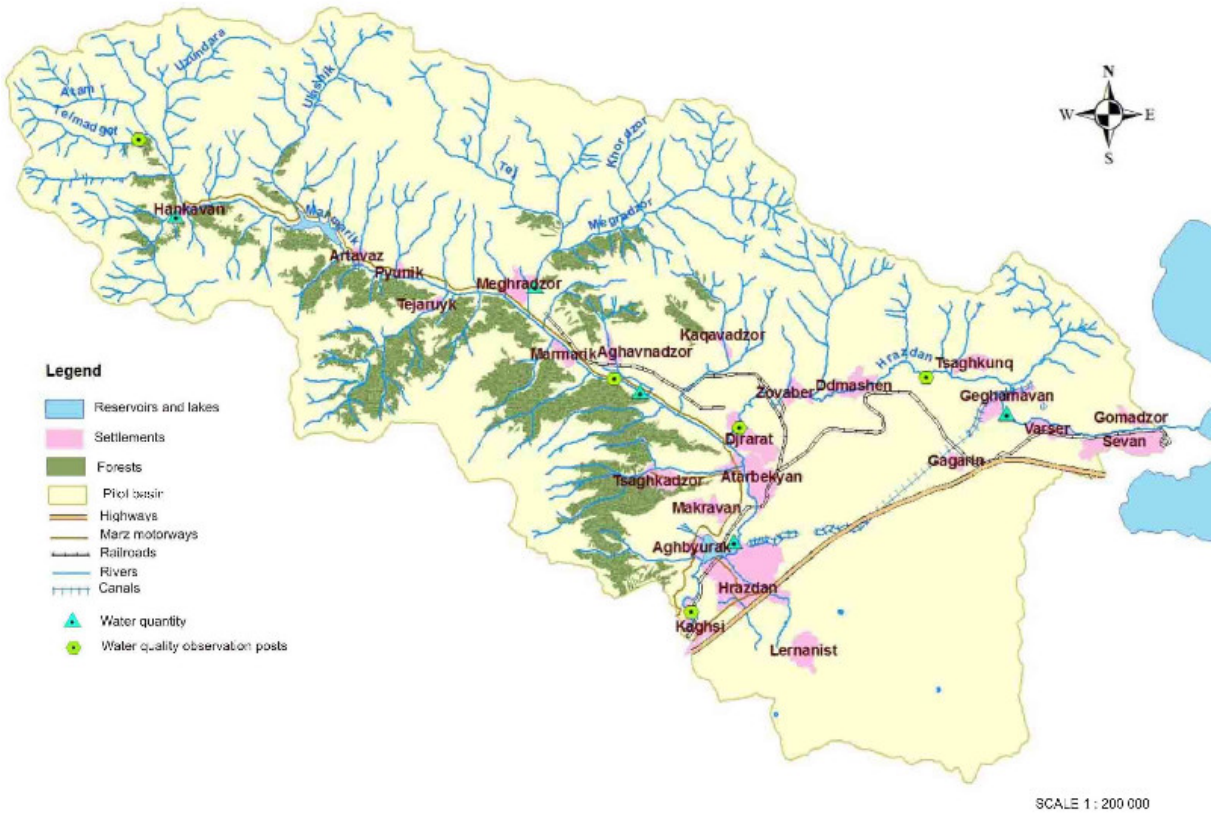


Figure 5: Hydrology of the Pilot River Basin

Table 4 presents the main hydrological characteristics of the hydrological observation posts in the upper Hrazdan River basin.

Table 4: Hydrological characteristics of Hrazdan basin according to hydrological observation posts

River-observation post	Years of operation	Watershed area, km^2	Perennial average discharge, m^3/sec	Flow module, $l/sec.\ km^2$	Flow volume, $mln.\ m^3$	Flow layer, mm	Maximum discharge, m^3/sec	Minimum discharge, m^3/sec
Marmarik-Hanqavan	1957-until now	93.5	1.67	17.2	52.7	564	31.3	0.12
Marmarik-Aghavnadzor	1942- until now	375	4.83	12.9	152	406	86.7	0.14
Gomour-Meghradzor	1936- until now	101	1.56	15.4	49.2	487	50.6	0.01
Ulashik-Artavaz (Takyarlou)	1970-1987	39.4	0.88	22.4	0.03	721	12.2	0.071
Shoumlar-Karakala	1958-1960	2.10	0.016	11.0	0.50	346	0.28	0.000
Artavaz (Qyoroghli)-Artavaz	1958-1960	8.50	0.12	16.5	3.78	520	1.67	0.000
Hrazdan-Geghamavan (on the canal)	1944- until now	4790 43.0	13.3	-	-	-	-	-
Hrazdan-Hrazdan	1965- until now	5330 697	7.77	5.09	244	162	66.3	1.43
Hrazdan-Qaghsi	1928-1939	780	14.1				137	4.10
Tsaghkadzor-Tsaghkadzor	2010-until now	23.1	0.019	0.82	0.599	25.9	-	-

As seen from table 4, the lower section of the river basin Hrazdan River (mainly including waters of Marmarik River) and the Hrazdan derivation channel together have an annual water discharge of 7.77+13.3=21.07 m^3/second.

Taking into consideration that the derivation channel is transit for the upper Hrazdan basin, and does not play a significant role in water use, we considered in the water-economic balance of the basin only the water discharge passing through the river - 7.77 m^3/second.

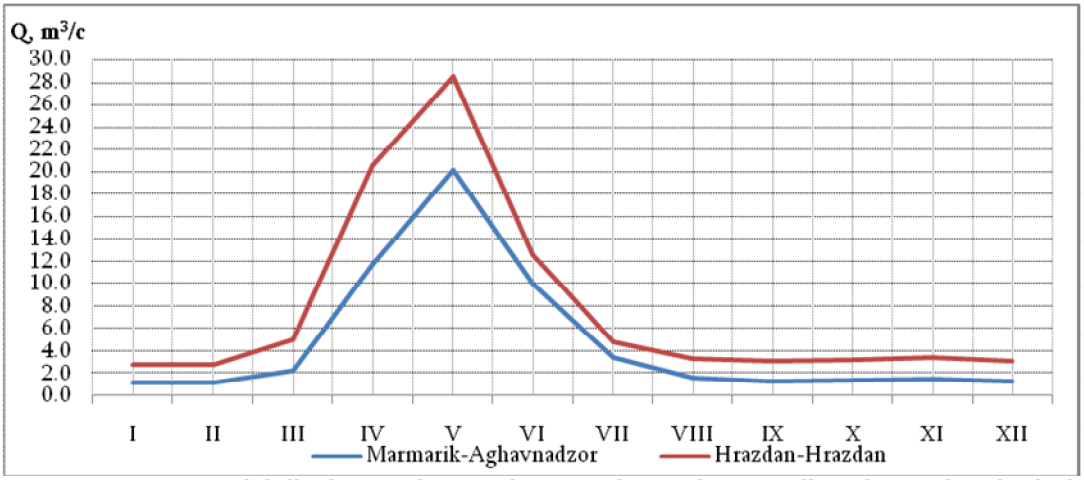


Figure 6: Average perennial discharges in Hrazdan-Hrazdan and Marmarik-Aghavnadzor hydrological observation posts

Throughout the year the river flow is distributed unevenly (Figure 6). The major part of the river flow is formed during the spring inundations and during the summer and winter seasons the river is water stressed. The main feeding sources of Hrazdan River are snowmelt, precipitation and groundwater. For Marmarik River the main feeding source is snowmelt, which composes 55%, whereas the other feeding sources are much less (precipitation waters - 18% and groundwater - 27%).

In order to provide for scientifically justified complex and rational use and protection of water resources of the basin, and in order to maintain the natural regime of the River, on March 23, 1981 a Decision No. 148 of the Council of Ministers of the Armenian Soviet Socialist Republic was adopted on "Establishment of Hydrological Reserve in the Upstream Part of Marmarik River". The territory of the Hydrological Reserve is defined from the mouth of Marmarik River until its end, village Hanqavan, with a territory of 93.5 km^2.

The territory of the river basin includes 2 reservoirs: Aghbyurak (Akhpara) and Marmarik (Table 5). The Aghbyurak reservoir provides for production of electricity by the Sevan-Hrazdan Cascade of HPPs. Marmarik reservoirs is close to construction and will be put into operation in mid 2011. The reservoir has mainly irrigation purposes and will provide irrigation water for land areas in the Marmarik River basin and middle and lower sections of Hrazdan River, which together compose about 1200 ha. Taking into consideration the favourable natural-climatic conditions of the territory, Marmarik River basin will also be used for recreational purposes and fisheries.

Table 5: Characteristics of the reservoirs

Reservoirs	Total volume, mln. m^3	Height of the dam, m	Area, ha	Purpose of use
Aghbyurak (Akhpara)	5.6	14.5	170	Energy
Marmarik[13]	24.0	55	250	Irrigation, recreation, fisheries

[13]) Marmarik reservoir will be put into operation in September, 2011.

Figure 7: Aghbyurak Reservoir

The largest water source in the river basin is the group of Atarbekyan and Maqravan springs, which together have a discharge of 1800 l/second. Maqravan springs are furnished with water abstraction capitations and pump water into the transmission pipelines. Despite the fact that the water captation structures concrete walls, which separate them from the river, in Aghbyurak reservoir and Hrazdan River often due to extreme increases of water levels the river waters confluences with the discharges of water sources.

3.7. Natural Hazards

In the territory of the river basin several there are several mudflow-prone areas, including the right tributaries of Marmarik River (Meghradzor, Aghavnadzor and Kaqavadzor), as well as several left tributaries of Hrazdan River (before the confluence with Marmarik River). The above-mentioned mudflows are considered of average level and the frequency of their occurrence is 3-10 years. According to their structure mudflows are either water-filth or water-stone types.

Bank erosion is common in the upper Hrazdan River basin, whereas the spatial erosion is not widely distributed. The bank erosion is observed during the spring inundations in the lower sections of Marmarik River basin (Marmarik River - 12 km, and Gomur River - 4k km).

The spatial erosion is observed in the southern slopes of Pambak mountain range, as well as in the forest-covered areas of Tshaghkunyatz mountain range, where intensive deforestation has occurred. These forests were seriously damages by illegal felling of 1990s, which was mainly due to economic and energy crisis and absence of centralized hearing system. According to estimates about 180-200 ha were deforested during those years.

The landslides are not very common for the river basin. They are mainly distributed in the left bank of Marmarik River and are weak.

Snowstorms are mainly observed in the upper sections of the Tsaghkadzor River, during the months January-March. They cause damage to the sport-complex zone of Tsaghkadzor city (close the ski routes, damage the forests, etc.).

3.8. Water Quality

3.8.1. Hrazdan River Water Quality

Monitoring of Hrazdan River water chemical quality has been implemented since 1986 in 6 water quality sampling points approved by the Ministry of Nature Protection of Armenia. Within this study the section of Hrazdan River from the river source until the Qaghsi wastewater treatment facility have been analyzed. In that section of the river water quality monitoring is implemented in two

sampling sites - sampling site no 51 below Geghamavan and sampling site no 52 below Qaghsi. In the samples taken in the period 1986-2004 24 water chemical parameters were detected (see Figures 8-11), as well as organo-leptical indicators. Sampling, conservation of samples and measurements has been conducted according to approved procedures. In the period of 2005-2010 35-45 indicators have been detected in the samples according to ISO and EPA standards.

Peculiarities of the current conditions of river's water - According to the results of monitoring of 1986-2010 the waters of the river have low pH, and the values of pH in the upper and lower sections of the basin are stable and close to each other. The oxygen regime of the river is in good condition. This is due to the fact that in the observed section of Hrazdan River the self-cleaning property of the river is rather intense.

In the sampling sites at river source and Qaghsi sampling point a slight and gradual increase of suspended solids is observed (Figure 8). Concentrations of the same order are observed also in Marmarik River mouth. During the recent years the increase of suspended solids in the waters of river basin is mainly due to three factors: increase of volumes in construction, cement production and communal-household wastewater.

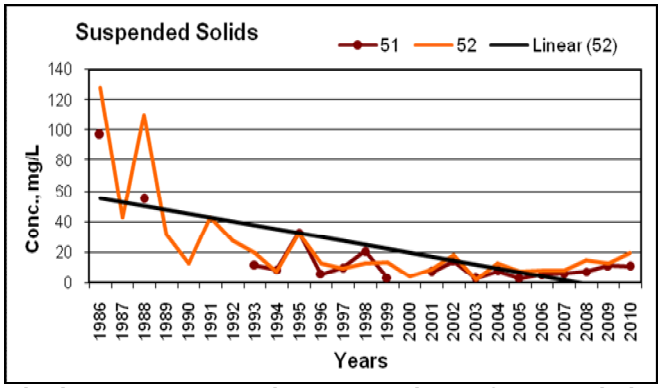
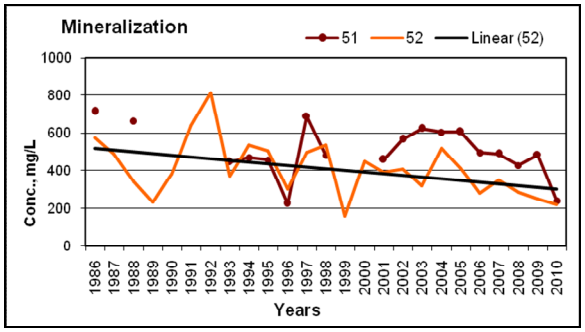
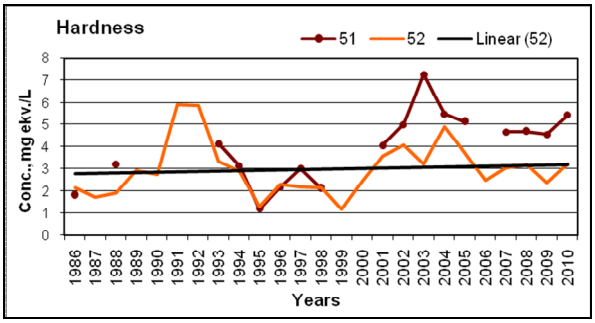
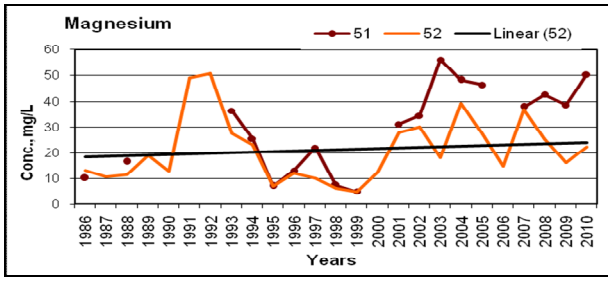
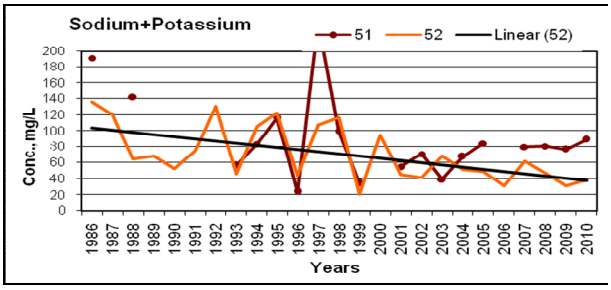


Figure 8: Changes in the average annual concentrations of suspended solids in 1986-2010









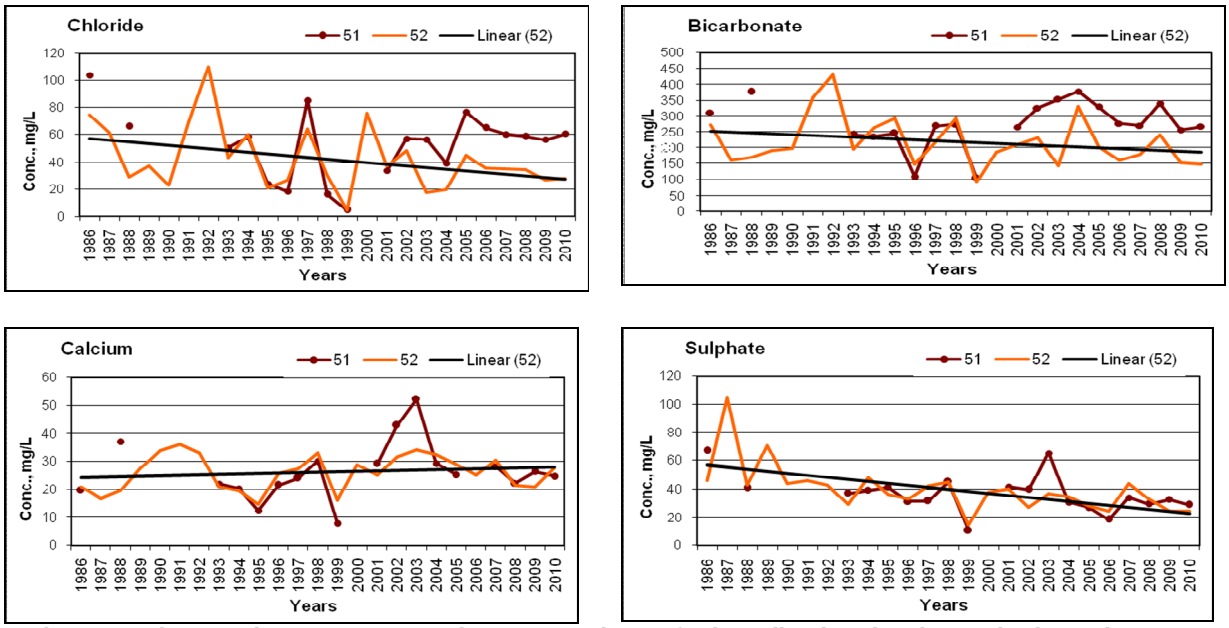


Figure 9: Changes in average annual concentrations of mineralization, hardness, hydrocarbonate, chloride, sulphate, magnesium, calcium, potassium and sodium ions in 1986-2010

Compared to concentrations observed in Hrazdan River source the concentrations of total mineralization, hardness, hydrocarbonate, chloride, magnesium, potassium and sodium ions in Qaghsi section of the basin are low and this difference is observed during the last decade. The fact that the concentrations of the above-mentioned six indicators in the Qaghsi section of the river are lower compared to the concentrations in the river source, as well as the synchronic tendencies, show that the dynamics and process are contingent upon the same factor. Most likely outflow water from Lake Sevan until 2000 has had a large share in Hrazdan River. Limitations of outflow from Lake Sevan, employed during the last decade, have increased the portion of waters from Marmarik River and thus have impacted the quality of water. Since the concentrations of all six above-mentioned indicators in the waters of Marmarik are significantly less than the corresponding concentrations in the waters of Hrazdan River source, then after the confluence the concentrations decrease and get closer to the values of concentrations of Marmarik River. At the same time, there is a possibility that during the last decade the hydrogeological changes occur in the entire watershed, thus implying changes in chemical composition of river's water. The nature and scale of these changes are still unclear. That is why special targeted studied need to be conducted.

The values of concentrations of calcium and sulphate ions (Figure 9) during 1986-2010 have changed in the river source and Qaghsi section of the river in harmonic manner and practically coincide. The professed absence of impact on Marmarik River waters on the concentrations of calcium and sulphate is due to the fact, that their values in the Marmarik River mouth and the sections of Hrazdan River being analyzed are close to each other and after the confluence no thinning out occurs.

The changes of the average annual values of BOD_5, which is an index of organically easily oxidable substances, shows that in this section an inflow of communal-household wastewater occurs. The same picture is for the case of COD.

As seen from Figure 10 in the Qaghsi section of the river the average annual concentrations of phosphate, nitrite, ammonium and nitrate ions since 2004 are several times higher than the average annual concentrations of the same parameters in Hrazdan River source or at Marmarik River mouth. Thus, it is clear that during the recent years, after the confluence with Marmarik River in the Qaghsi section there is an inflow of communal-household, agricultural and livestock breeding wastewater, which is colligated with intensive aeration.

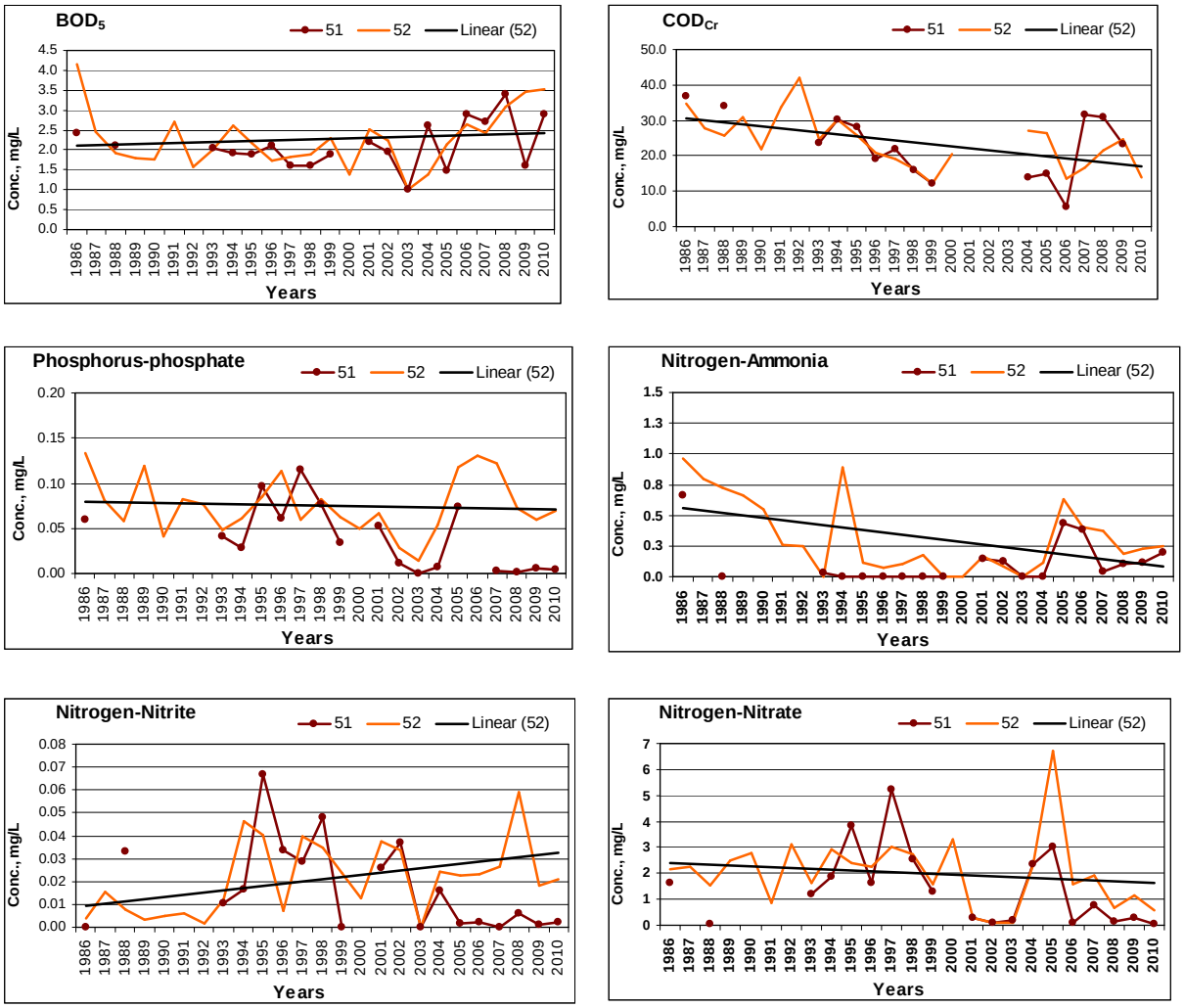
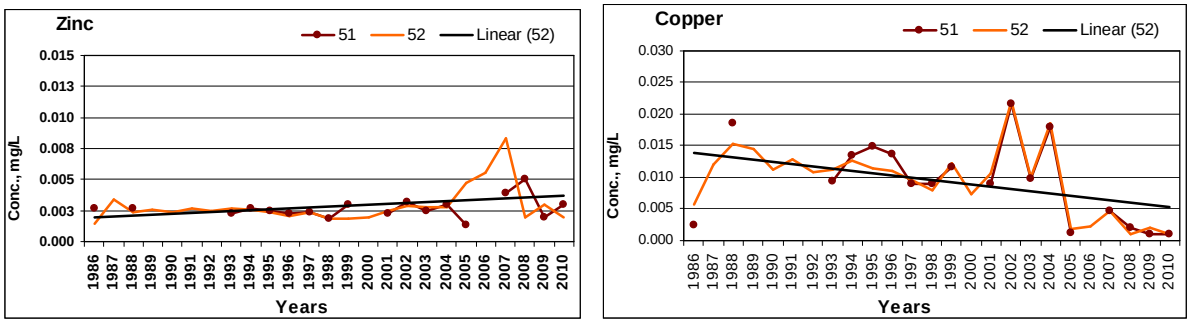


Figure 10: Changes in the average annual concentrations of BOD_5, COD, ammonium, nitrite, nitrate and phosphate ions in 1986-2010

In the period 2005-2010 the concentrations of zinc and copper in the river source and Qaghsi section area of the same order and are close to the concentrations of the same parameters observed in Marmarik River mouth. All of them correspond to all existing norms (Figure 11).

During the recent years in Qaghsi section of Hrazdan River an increase of iron concentration is observed, which is mostly due to the impact of water from Marmarik River, which on its turn is contingent upon deforestation in the watershed and subsequent erosion and strong winds, as well as significant increase of alluviums due to soil washing and intensification of inflow of communal-household wastewater.



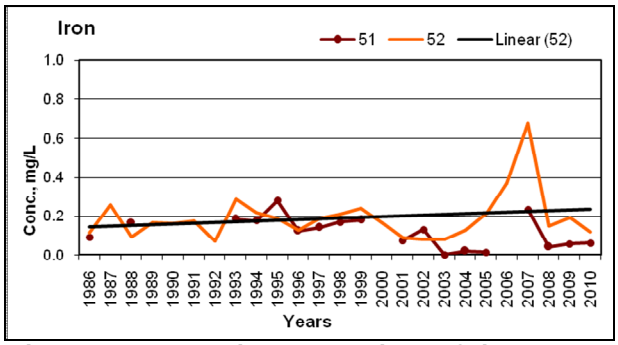


Figure 11: Changes in the average annual concentrations of zinc, copper and iron in 1986-2010

General conclusions on Water Quality of Hrazdan River

- From the river source until Qaghsi section Hrazdan River's water quality mainly corresponds to norms accepted for fisheries, industrial, irrigation and energy water uses,
- In Qaghsi section the concentration of total mineralization, anions and cations, as well as hardness significantly decrease due to confluence with Marmarik River,
- In Qaghsi section the water quality deteriorates, which is particularly expresses through increase of concentrations of nitrogen and phosphorous compounds, particularly during the last 5-6 years,
- During the last 5-6 years in Qaghsi section of the river an inflow from communal-household, agricultural and livestock breeding wastewater exists, colligated with intensive aeration,
- In Qaghsi section of the Hrazdan River during the last 5-6 years another major factor of pressure is also reduction of forest coverage, which causes increase in erosion, weathering, in washing of soils.

3.8.2. Marmarik River Water Quality

Water quality monitoring of Marmarik River is being conducted since 1986, by the Environmental Impact Monitoring Centre of the Ministry of Nature Protection of Armenia. There are two water quality sampling sites (No. 57 and No. 58), one of which is upstream of the river, and the other one near the river mouth (see Picture 6). 24 water-chemical indicators have been determined in samples taken within the period 1986-2004 (see Table 20). Sampling, conservation of samples and analysis has been conducted according to existing regulations. For the period 2005-2010, 35-45 water-chemical indicators have been analyzed according to ISO and EPA standards.

Peculiarities of the current condition of river's water quality - The waters of the river are alkaline, and the values of pH in the upper and lower sections of the river are close to each other and stable. The oxygen regime of the river is in good condition. The waters of the river have average hardness and average mineralization.

The pollution with nitrate, nitrite, ammonium and phosphate ions, BOD_5, and COD has unstable nature and low level. The impact of this group of pollutants is contingent upon anthropogenic factors, including the use of fertilizers and inflow of agricultural and communal-household wastewater. As seen from the figures the average annual concentrations of the above-mentioned indicators are within the norms in the river source, whereas for ammonium ions and BOD_5 the corresponding norms are exceeded, which shows some anthropogenic pressure alongside the river.

The concentrations of the metals Cu, Mn, V are stable and exceed the maximum allowable concentrations (MACs) for fisheries. The concentrations of Cu, Mn, V in the river source and river mouth do not differ significantly, which shows that their concentration for Marmarik River has background nature and is due to geochemical and hydro-geological peculiarities of the territory and watershed.

Pollution with the indicators of suspended solids, Zn, Fe and Al is unstable and is higher in the river mouth than in the river source. The concentration of the above-mentioned indicators in the river is increased in the period of snowmelt and spring inundations. From the river source until the river mouth a slight increase and exceedence of the average annual MACs is observed. The increase of concentration of suspended solids, observed during the recent years, is due to extension of activities of the resort houses in Marmarik River basin, which on its turn brings to increase construction works and increased tourism to the resort zone.

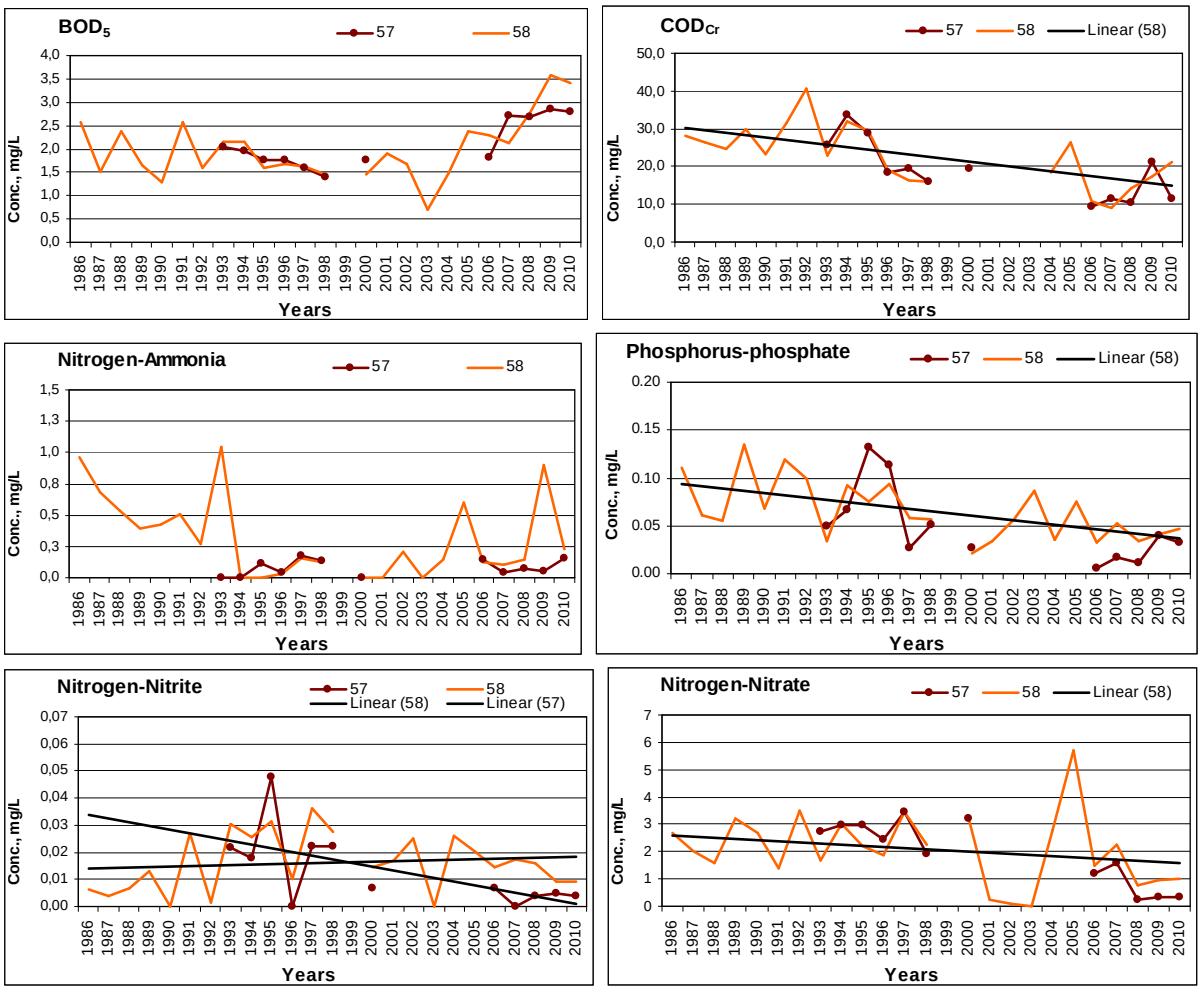


Figure 12: Changes in the average annual concentrations in nitrite ions in 1986-2010

In the period 2005-2010 in the upper section of the river a significant reduction of the concentrations of calcium, magnesium, potassium and sodium, chloride and sulphate ions is observed, as well as changes in the ration calcium/magnesium are recorded. This ration was 1:1 in 1986 and has increased and now composes 2:1. These changes imply that during the last decade certain hydrogeological changes in the watershed occur.

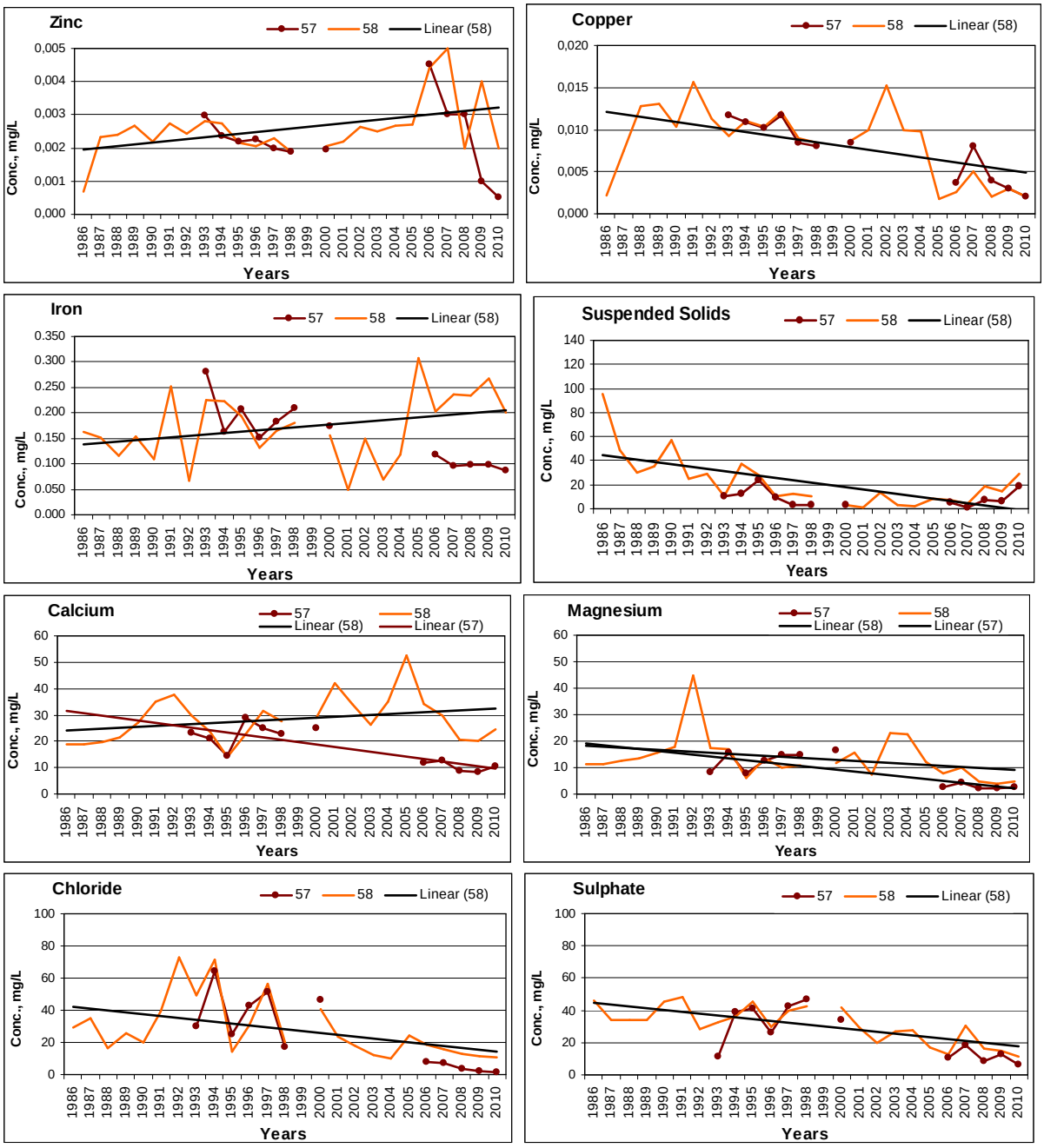


Figure 13: Changes in the average annual concentrations of calcium in 1986-2010

General conclusions about the quality of Marmarik River water

- Water quality in Marmarik River is of good order for the fisheries, communal-household, drinking and irrigation purposes,
- Due to anthropogenic pressures the concentration of nitrogen compounds decreases, however, at the same time still being at rather high level,
- High concentration of metals Cu, Mn, V in river's water is due to geochemical and hydrogeological peculiarities of the watershed,
- The concentration of the suspended solids, Zn, Fe and Al in the river's water increases during spring inundations and as a result of construction works.

3.8.3. Tsaraghbyur River Water Quality

Tsaraghbyur River water quality chemical monitoring is implemented since 2008 in two sampling points (n 311 and no 312) approved by the Ministry of Nature Protection of Armenia. These sampling sites are located correspondingly near the river source and river mouth. In the samples taken during 2008-2010 45 water chemical indicators have been determined according to ISO and EPA standards. Sampling, conservation of samples and measurements are implemented according to the existing procedures.

Peculiarities of the current condition of river's waters - The waters of Tsaraghbyur River are slightly alkaline. The water of river has average hardness. The oxygen regime of the river is in good condition. This is due to the fact that the river has turbulent flow due to its fast flow and hydromorphology, which on its turn brings to saturation with oxygen and high potential of self-cleaning. It is relatively low during the months June-August. This is explained by two factors. First, due to increase of temperature, the concentration of dissolved gases, including dissolved oxygen, decreases. Second, during the low flow period as a result of anthropogenic pressure the oxygen discharge increases of biochemical processes.

Increase in concentration of the suspended solids (Figure 14) is observed during the spring and fall seasons, which is due to snowmelt and precipitation. In the upper and lower reaches the concentration of suspended particles practically coincide, which tells about the absence of anthropogenic and natural factors which would promote the increase of concentration in suspended solids.

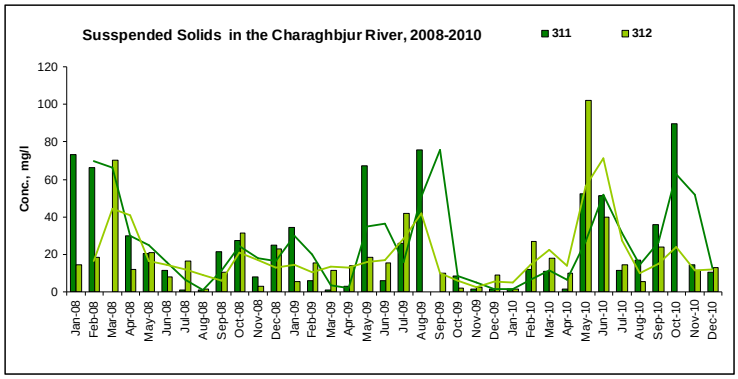
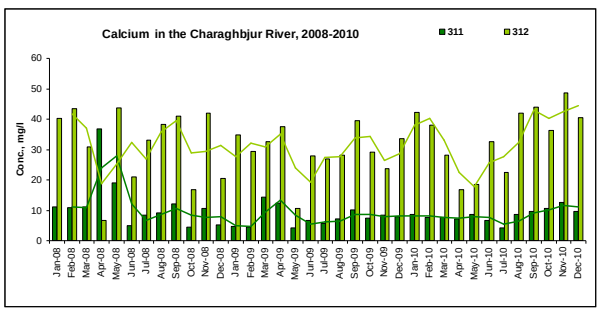
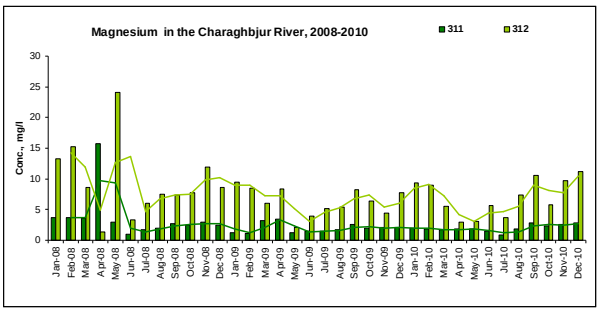


Figure 14: Monthly dynamics of the suspended solids in 2008-2010

In the river mouth (sampling site no 312) the concentrations of calcium and magnesium (Figure 15) are 3-4 times higher compared to the concentrations recorded in the river source (sampling site no 311), which is due t the geochemical composition of the given section of river. In the upper and lower sections of the river no seasonal dependency of calcium concentration is observed. The ration calcium/magnesium decreases in the lower section of river in winter and summer (in winter the decrease is more, compared to summer), and in other seasons this ration is 1.2-1.5 times higher compared to the upper reaches of the river.





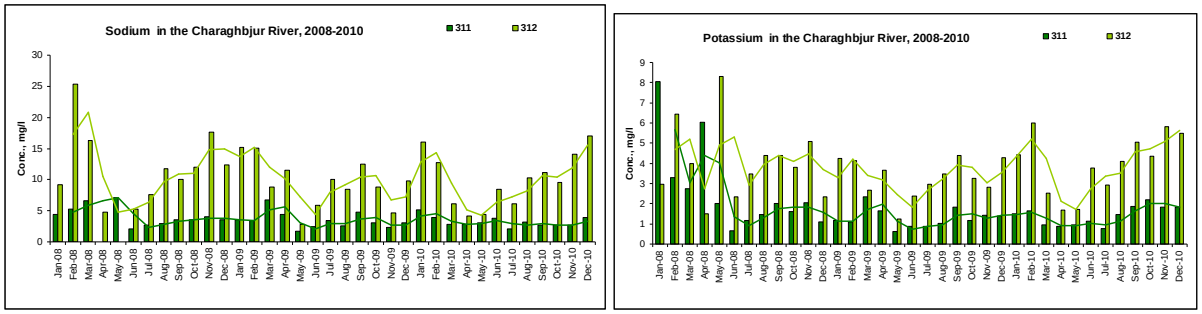


Figure 15: Monthly dynamics of the concentration of calcium and magnesium in 2008-2010

The seasonal fluctuations of the concentrations of hydrocarbonate ion, sodium and calcium are more significant in the lower sections of the river. Mainly due to spring snowmelt and precipitation the concentration decreases, whereas in other periods again increase of concentration if observed, which is due to composition of hydrogeology in that section of the river. The ratio Na/Na+Ca is subject to seasonal fluctuations and is higher in the sampling site in river source compared to the sampling site in the river mouth, which is due to large portion of groundwater feeding in the sampling site near the source.

The concentrations of sulphate and chloride ions (Figure 16) in the upper sections of the river did not undergo significant changes in the observed period. In the lower sections seasonal fluctuations are observed, with higher concentrations in winter and summer seasons.

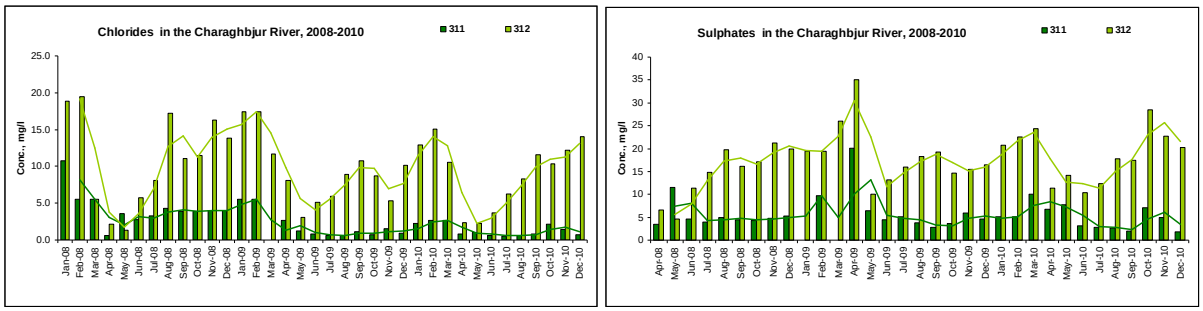
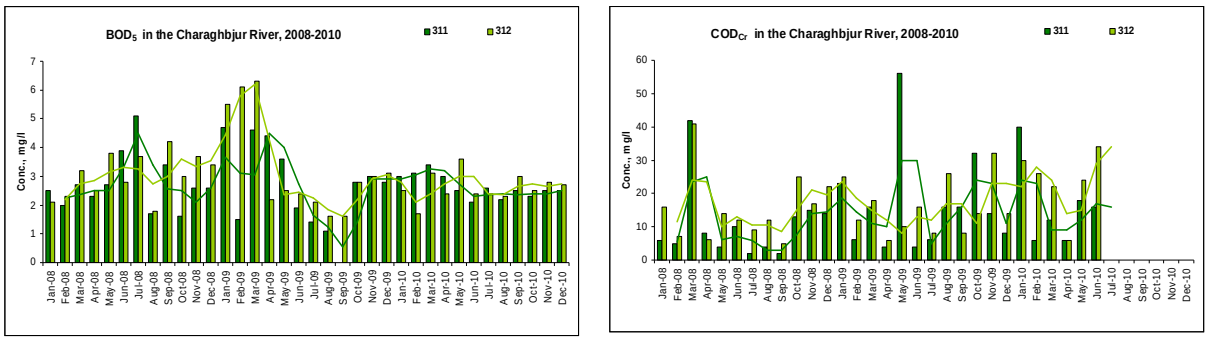


Figure 16: Monthly dynamics of chloride and sulphate ions in 2008-2010

The concentration of ammonium, nitrite, nitrate and phosphate ions and organic substances (Figure 17) increases downstream of Tsaghkadzor particularly in winter and summer seasons, which is due to increased tourists in that region and low-flow in river. In the months March-June, which coincide with the spring inundation period, a decrease of concentration is observed. This might be due to sharp increase of number of tourist centres and Tsaghkadzor in recent years. Since most of the tourist centres do not have wastewater treatment facilities, the sewerage is directly being discharged in the river and the concentration of the above-mentioned pollutants increases in the river particularly during the low-flow period. The second important factor is due to increased volume of deforestation in the watershed, particularly in the middle sections of the river.



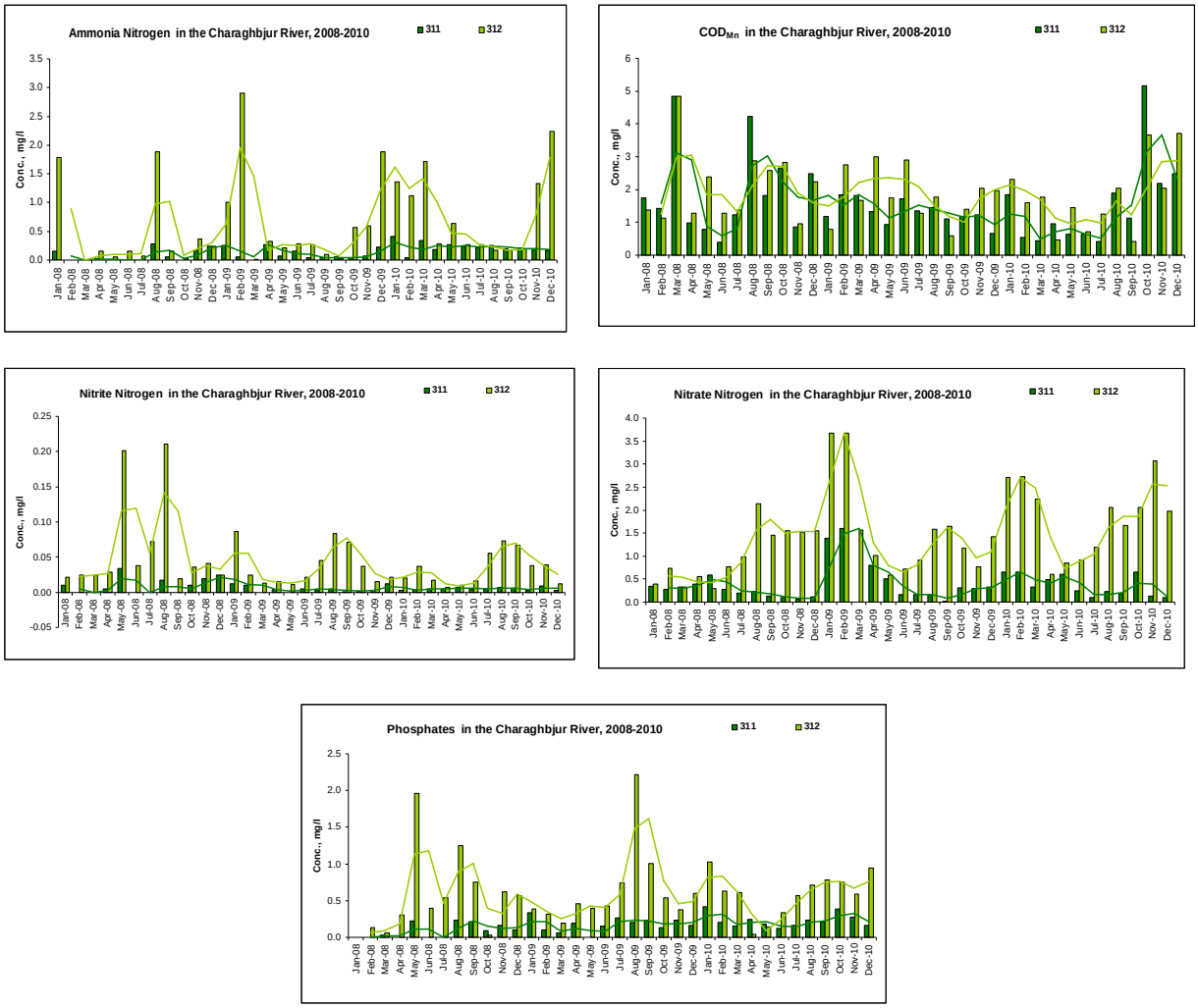
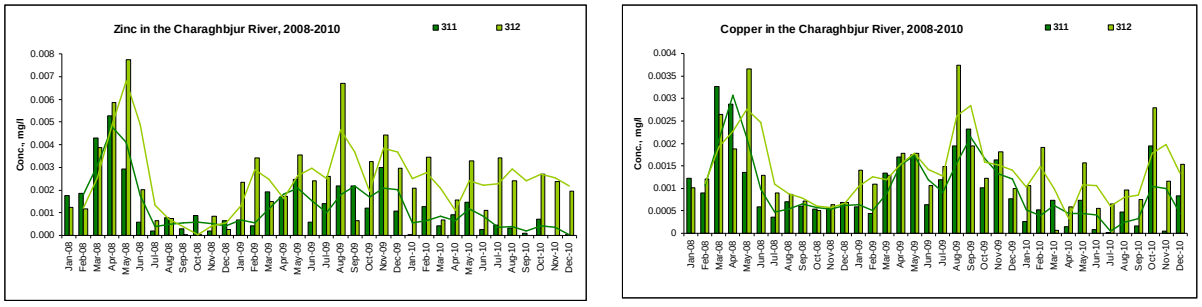


Figure 17: The monthly dynamics of concentrations of nitrate nitrogen, nitrite nitrogen and phosphate in 2008-2010

The concentrations of zinc and copper in 2008 have changed based on the season, with characteristic increases in spring (Figure 18). Moreover, during the spring inundation periods, when the snowmelt water is dominating in the river, in the upper reaches of the river the concentrations of zinc and copper are higher, compared to the lower sections of the river. Afterwards, due to precipitation the corresponding concentrations also increase in the lower sections. In 2009-2010 an increase of concentrations of zinc and copper is observed in the lower section of the river, which does not have seasonal nature. Thus, in the lower section the anthropogenic pressure has increased.



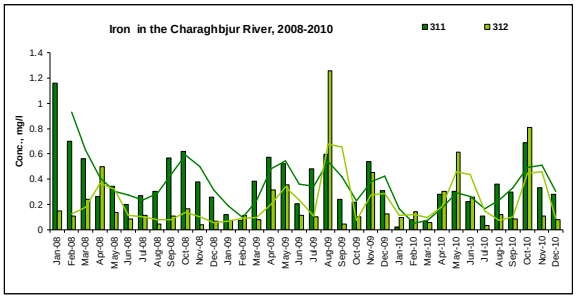


Figure 18: The dynamics of concentrations of the element copper in 2008-2010

Several general conclusions on waters of Tsaraghbyur River

- In the lower sections of Tsaraghbyur River, including Tsaghkadzor city, the water quality during the last three years, 2008-2010, is constantly deteriorating,
- In the low-flow periods the water quality in the lower sections of Tsaraghbyur River becomes of bad or poor class,
- Water quality deteriorations is mainly due to sharp increase of concentrations of organic pollutants of nitrogen compounds and phosphorous in Tsaghkadzor city and downstream of the city,
- Deterioration of water quality is partially due to increase concentrations in Tsaghkadzor and below the city,
- The oxygen regime of the river is satisfactory, which is dude to river hydromorphology,
- The moderate status of the oxygen regime of the river, as well as sharp increase of nitrogen and organic pollutants in the river particularly during the low-flow period show a point source pollution, indicating that the pollution is recent and its source is close to the water quality sampling point,
- Water quality deterioration is due to pressures from the communal-household wastewater in the territory of Tsaghkadzor city, which is increasing in recent years to sharp increase of number of tourists and tourist centre. Since most of these tourist centres do not have wastewater treatment facilities, in the territory of Tsaghkadzor the sewerage, without treatment directly discharges into the river. That is why the concentrations of organic pollutant, containing nitrogen and phosphorous, dramatically increases, particularly during the low flow period.

3.9. Demography

The upper Hrazdan River basin includes 3 cities from Kotayq and Gegharkunik marzes of Armenia (Hrazdan, Sevan and Tsaghkadzor) and 13 rural communities. As of January 1, 2010 the total population in the basin has composed 99,400 people, of which 50.7% were women and 49.3% men.

Table 6 presents the composition of urban and rural settlements of the river basin. The national composition of the basin is unitary, with about 98.5% Armenians, and the remaining being Russians, Greeks and other nationalities.

The natural population growth is measurable, and composes only 0.35% of the entire population.

The average density of the population is 127 people/km^2, and compared to other territories of the country this river basin is considered as densely populated.

Table 6: The population number in upper Hrazdan River basin as of 2010

No	Community name	Name of the settlement	Population number, people		
			Total	of which	
				men	women
	Kotayq marz				
1	Lernanist	Lernanist	3101	1546	1557
2.	Qaghsi	Qaghsi	2235	1146	1122
3.	Hanqavan	Hanqavan	147	60	87
4.	Artavaz	Artavaz, Pyunik	1058	524	534
5.	Meghradzor	Meghradzor	2747	1388	1359
6.	Marmarik	Marmarik	862	430	432
7.	Aghavnadzor	Aghavnadzor	1364	684	680
8.	Tsaghkadzor	Tsaghkadzor	1608	785	823
9.	Hrazdan	Hrazdan, Kaqavadzor, Maqravan, Atarbekyan, Aghbyurak	53200	26546	26654
	Gegharkunik marz				
11	Ddmashen	Ddmashen	2868	1427	1441
12	Zovaber	Zovaber	1778	827	951
13	Sevan	Sevan Gagarin	23162	11067	12095
14	Tsaghkunq	Tsaghkunq	1191	581	610
15	Varser	Varser	2026	1003	1023
16	Geghamavan	Geghamavan	2030	995	1035
	Total		**99377**	**49009**	**50403**

The urban population is dominant and composes 78% of the total population of the basin. Such high proportion of urban population is related to industrialization of Hrazdan city. Currently about 21% of population able to work in Hrazdan city is unemployed, since many industrial enterprises are inoperational.

Pensioners compose about 19% of the entire population of the basin.

It is expected that the population will not increase in the basin in the near future taking into consideration the following factors: socio-economic condition of basin's population; high rate of emigration and loss of young and qualified work force; measurable natural growth of the recent years; and global financial-economic crisis. At the same time, due to that fact that most of the industrial enterprises in the basin are inoperation, it is expected that due to internal migration people will move from previous industrial, urban settlements into the rural settlements.

3.10. Economy

3.10.1. Industry

Industry is one of the most important branches of economy in the river basin.

During the recent years the economy of the pilot river basin has undergone significant structural changes, the machinery and equipment production sectors have declined, whereas the food production, tourism and other industries have increase their weighted share in the industry of the basin.

In the basin there are numerous organizations involved in energy sector, machinery, construction, food production, mining and other production activities.

Currently in the river basin there are over 40 industrial enterprises, over 95% of which are private. The main industrial branches of the river basin are energy production, construction materials, food production, light industry, mining, resort services and service sectors.

Hrazdan city is considered as major industrial centre.

As of 2010 there are several large industrial enterprises operating in the upper Hrazdan River basin, including the "ArmRusGasProm" CJSC Hrazdan Thermal Power Plan, "Mika" Cement Factory, Meghradzor gold mine, and bottling of water by "Tezh-Sar" resort house complex (Table 7).

Among the food production industry the main actors are bread and dairy production, which have local significance. The private enterprises acting in the industry sector have small-scale production, which can not have significant impact on the production volumes and on industrial water use.

Table 7: Characteristics of the Industrial Enterprises in Pilot River Basin

Name of the enterprise	Branch of industry	Type of production	Volume
"Aradz" LLC Meghradzor gold mine	Mining	Gold ore	-
"Mika Cement" CJSC	Construction materials	Cement	300000 ton
"Tezh Sar" resort house complex - bottling of water	Food production	Production of mineral waters	
"HarRusGasProm" CJSC, Hrazdan Thermal Power Station	Energy production	Electricity	1110 kWt hour
"Energatzantzshin" JSC, small HPP	Energy production	Electricity	4200000 kWt hour
"Tezh Waterfall" LLC small HPP	Energy production	Electricity	6300000 kWt hour
Hanqavan-1, HPP	Energy production	Electricity	2710000 kWt hour

3.10.2. Agriculture

Livestock breeding is one of the branches of agricultural in the pilot river basin. During the last 15 years the number of cattle heads has gradually decreased in the basin. This is mainly due to the fact that there are difficulties in terms of selling the output of the animal husbandry, which are contingent upon population migration and reduction, low level of population's purchasing ability, low percentage of artificial fecundation of livestock, deteriorated condition of the cattle-sheds and others.

Table 8 presents the livestock breeding branches in the pilot river basin according to communities and types (cattle, pigs, horses and poultry), including the livestock number.

Table below presents data only about the livestock number possessed by the population in the communities. As seen from table 8 in the pilot river basin mainly cattle, prigs, sheep, goats, horses and poultry are bred. The number of pigs is very few, since during the recent years their number has dramatically decreased due to epidemics.

Table 8: Livestock number in pilot river basin as of 2010, heads

Communities	Cattle	Pigs	Sheep, goat	Horses	Poultry
Kotayq marz					
Hrazdan	3051	466	2116	25	8597
Tsaghkadzor	32	3	-	-	50
Aghavnadzor	391	22	346	10	348
Artavaz	267	16	168	7	473
Lernanist	840	23	1687	5	847
Hanqavan	110	5	-	-	115
Marmarik	359	11	503	8	806
Meghradzor	882	83	1335	6	2143
Jrarat	174	41	-	-	530

Communities	Cattle	Pigs	Sheep, goat	Horses	Poultry
Qaghsi	466	23	985	7	882
Gegharkunik marz					
Sevan	2300	226	3191	16	4576
Geghamavan	903	18	941	3	764
Tsaghkunq	980	14	1932	5	1573
Ddmashen	1398	25	2396	9	2417
Varser	1469	13	1820	4	1692
Zovaber	1012	22	1626	6	1441

Livestock is mainly fed by pasture food. Their productivity is low due to the fact that the food quality is slow, the sown areas which service as fodder for them has reduced, and the previously existing system of mixed fodder supply does not operate any more.

Several small livestock breeding farms operate in the basin, each of which has 50-100 cattle. These farms of located in Hanqavan, Meghradzor, Hrazdan and other settlements.

Poultry breeding - In the pilot river basin the communities posses about 27,300 poultry. In addition to this, there is only one poultry-breeding farm in Gagarin, where the number of poultry is 20,000.

Crop production- From the crop-production agriculture the following is common for the basin: grains, potatoes, small quantity vegetables (cabbage) and forage crops. From perennial plantations the following fruits: drupaceous and nuciferous.

4. ANALYSIS OF NATURAL RESOURCES USE

4.1. Landscapes

Parallel to development of economic activities in the pilot river basin the landscapes of the basin have been significantly impacted. The vegetation in the alpine and sub-alpine high mountainous meadows, as a rule are reduced and degraded. Some of the reasons for degradation of vegetation cover in the meadows include the following: improper grazing in pastures, unregulated roads made and opened by the drivers, absence of passes for livestock, unregulated collection of some volatile-oil-bearing plants, edible plants, medicinal herbs and field flowers by population. In addition to this in recent year the population also fires the pastures. As a result of firing pastures the root part of the grass cover of pastures is weakened, several rare plants are disappearing, the soil surface is denudates, which becomes a reason for activation of erosion processes. During the recent years fires have become common in sub-alpine and alpine zones of Pambak mountain range. That is why a decent attention shall be paid to the issues of protection of landscapes.

In the pilot river basin forests are being used for timber collection, cultural, sporting, resorts and recreational purposes. Forests are used by local population for their needs, including timber, forest fruits and berries, mushroom and other. In the forests close to the settlements also cattle-grazing takes place, which is having a negative impact on the regeneration of forests due to destruction of saplings, seeds and others.

Due to energy crisis of 1990s in the territory of Armenia, including the pilot area, forests were illegally felled and a significant damage was caused to forests. In the pilot river basin deforested areas include territories close to the settlements Hanqavan, Meghradzor, Tsaghkadzor, Aghavnadzor, Hrazdan and other settlements, as well as territories close to river basins and forest paths.

The most significant anthropogenic impact due economic activities in pilot river basin is observed in the steppe landscapes, since the settlements, industrial enterprises, agricultural lands and other economic objects are located in this zone.

Detailed description of the use of this zone is presented below.

4.2. Land Use

The land reserves in the pilot river basin compose approximately 78,000 ha, 65% of which are agricultural lands, 9.3% are forests, 3% bushes, and 23% other lands.

The main role in land use in the basin belongs to pastures, plough-lands and arable lands, which are located in the steppe landscapes of middle and lower reaches of Marmarik River, as well as bank territories of the upper reaches of Hrazdan River.

About 13% of the total agricultural lands of the basin are pastures, which are located at the altitude of 1700-2000 m, 19% are plough-lands, and 0.5% gardens.

Thanks to plenty precipitations (annual 600-650 mm) the irrigated lands occupy a small territory in the basin, only about 4.1% of the total area of agricultural lands. Of this, 89% are pastures. Table 9 presents the use of agricultural lands of upper Hrazdan River basin, according to communities.

Table 9: Land Use in the Pilot River Basin, ha

Name of the community		Arable land		Perennial plantations	Natural grazelands			
					Adjacent to settlements		Far from settlements	
		irrigated	dry farming		grassland	pasture	grassland	pasture
1.Lernanist	homestead land	58.0	11.0	20.0	-	-	-	-
	total	624.9	778.3	20.0	356.6	1312.0	60.0	150.0
2. Qaghsi	homestead land	37.0	13.0	33.0	-	-	-	-
	total	191.1	815.9	64.0	458.0	585.0	100.0	265.0
3. Hrazdan	homestead land	31.0	8.0	26.0	-	-	-	-
	total	193.6	1453.4	32.9	607.0	269.0	67.0	130.0
4. Tsaghkadzor	homestead land	-	12.0	8.0	-	-	-	-
	total	-	12.0	8.0	-	-	-	-
5. Jrarat	homestead land	35.0	35.0	55.0	-	-	-	-
	total	803.3	583.7	105.0	503.0	566.0	-	-
6. Hanqavan	homestead land	10.0	17.0	15.0	-	-	-	-
	total	18.9	393.8	18.0	743.0	2196.0	-	30.0
7. Artavaz	homestead land	60.0	16.0	-	-	-	-	-
	total	430.3	877.9	-	55.0	397.0	150.0	250.0
8. Meghradzor	homestead land	73.0	12.0	6.0	-	-	-	-
	total	295.8	134.5	6.0	740.0	1009.0	-	345.0
9. Marmarik	homestead land	32.0	3.0	1.0	-	-	-	-
	total	69.5	112.7	5.8	108.0	350.0	-	.
10. Aghavnadzor	homestead land	42.0	6.0	2.0	-	-	-	-
	total	165.0	108.1	2.0	140.0	350.0	-	-
11. Zovaber	homestead land	38.0	17.6	-	-	-	-	-
	total	180.0	398.6	-	90.0	572.0	251.0	53.0
12. Ddmashen	homestead land	60.0	20.0	-	-	-	-	-
	total	140.0	849.0	-	607.0	1028.0	-	281.0
13. Tsaghkunq	homestead land	40.0	2.2	-	-	-	-	-
	total	123.2	796.0	-	607.0	1240.0	-	-
14. Geghamavan	homestead land	30.0	36.0	-	-	-	-	-
	total	95.5	792.6	-	157.0	708.0	89.0	28.0
15. Varser	homestead land	21.0	61.0	-	-	-	-	-
	total	188.3	1382.7	-	318.0	900.0	39.0	260.0
16. Sevan, city	homestead land	-	-					
	total	-	120					
	total homestead land	567	296.8	166.0	-	-	-	-
Total		3519.4	9489.2	261.7	5489.6	11482.0	756.0	1792.0

4.3. Water Supply and Water Use

In the pilot river basin the water is mainly used for the drinking-household, industrial and irrigation purposes. Also the potential of the water for energy production is being used through hydropower stations.

For drinking-communal purposes the water is being supplied by the Armenian Water Supply and Sewerage Company (AWSC) CJSC. Particularly the North-eastern branch of AWSC supplies drinking water to the cities Hrazdan and Tsaghakdzor of Kotayq marz, as well as settlements Qaghsi, Lernanist, Jrarat, Aghavnadzor, Meghradzor, Artavaz and Marmarik. In Gegharkunik marz the company supplies water to city Sevan, as well as settlements Geghamavan, Tsaghkunq, Ddmashen, Varser and Zovaber. According to the decision no 71-N of February 27, 2009 of the Public Service Regulatory Commission of the Republic of Armenia tariff for drinking water supply is set 154.47 AMD/m^3, for water discharge 25.31 AMD/m^3, and the wholesale tariff for drinking water supply is 51.49 AMD/m^3.

Table 10 below presents information on water users of the upper Hrazdan River basin. As seen from the table, annually for ***drinking-communal*** purposes about 43.3 million m^3 of water is being used, for ***industrial*** purposes about 12.2 million m^3 of water is being used, and for ***irrigation***

purposes annually about 2.5 million m^3 of water is being used. The major share of water use for drinking-communal purposes belongs to drinking water supply to Hrazdan city, and for water use for industrial purposes - Hrazdan Thermal Power Plant.

Interestingly, a group of small rural communities in Marmarik River basin takes drinking water from surface source (river), which is being supplied after treatment by the Ulashik water treatment facility. Such cases are very rare in Armenia.

Table 10: Water Use in the Pilot River Basin, mln. m^3

Name of water user (city, community, industrial enterprises)	Qualitative property of the water used (drinking, technical)	Water source (natural spring, groundwater source, surface)	Water abstraction volume	Volume of the return waters	Point of discharge of wastewater (water accepting object)
1. Drinking-household-communal water users					
1.1Hrazdan city	Drinking-communal	Groundwater (Maqravan groundwater source)	30.910	9.670	Hrazdan River
1.2 Tsaghkadzor city	Drinking-economic	Groundwater (Maqravan groundwater source)	4.005	1.001	Hrazdan River
1.3 Sevan city-neighbouring communities	Drinking-economic	Groundwater natural springs	7.740	4.080	Hrazdan River
1.4 Group of rural communities (5 villages)	Drinking-economic	Marmarik River (Ulashik water treatment facility)	1.890	____	_____
1.5 Other communities (villages, **resort houses)**	Drinking-economic	Natural springs	0.795	0.159	Sewerage collector
			43.340	14.910	
2. Industrial and production water users					
2.1 Electricity (Hrazdan thermal power station)	Industrial, drinking	Marmarik River, groundwater	8.370 0.470	2.462 0.263 0.470	Hrazdan River, Marmarik River, urban sewerage collector
2.2 Cement factory ("Mika")	Technical	Marmarik River	2.411	1.690 0.045	Marmarik River, sewerage collector
2.3 Industrial (gold mine) 2.4 Construction ("ArmRusGasProm")	Technical Technical	Tributary of Marmarik River Marmarik River	0.286 0.676 12.213	0.280 0.200 0.037 5.447	Marmarik River, sewerage collector
3. Hydroenergy (SHPP)	Surface (river)	Marmarik River	50.890	5.0890	Marmarik
3. Irrigation water users					
All communities, city Hrazdan, city Tsaghkadzor	Irrigation	Hrazdan and Marmarik Rivers	1.64* 0.95	- -	- -

*Illegal water use

Ulashik water treatment facility, which belongs to AWSC CJSC, is located in the middle sections of Ulashik tributary of Marmarik River, at the altitude of 1950 m above the sea level. It is constructed in 1980s. The capacity of the facility is 60 litre/second. To pipelines with diameters of 50 mm and 400 mm come out of the station. The pipeline with 50 mm diameter provides water to Hanqavan settlement through pump. However, currently the pump is inoperational, thus Hanqavan settlement does not receive drinking water from that source. The 400 mm pipeline supplies gravity water to

the settlements Artavaz, Marmarik, Megharadzor and Aghavnadzor. In the upper reaches of Ulashik River the previously existing fence of the sanitary protection zone is entirely stolen. Thus, the livestock has an easy access to the sanitary protection zone and pollutes the territory.

The main existing problems related to the treatment facility include the following: absence of the sanitary protection zone, inadequate treatment of water due to degraded and outdated equipment. In case of renovation and provision of new equipment, the water treatment facility will have a possibility to supply water with a capacity 100 litre/second.

Cities Hrazdan and Tsaghkadzor, as well as settlements Jrarat, Lernanist and Qaghsi are fed from the Maqravan water source, which has a discharge of 1800 litre/second. Annually, about 35-40 million m^3 water is being pumped to the above-mentioned settlements. The Maqravan springs do not have any protection structures. There are cases, when during the maximum flow Hrazdan River's water is mixed with the waters of Maqaravan springs. The waters of river deteriorate the quality of the spring waters and pose danger to human health.

From the settlements of Gegharkunik marz city Sevan received drinking water from Lchashen deep well and Dzknaget springs (together about 8 million m^3 per year), the settlements Varser and Geghamavan receive water from Dzknaget and Hatzarat springs, and the settlements Tsaghkunq, Ddmashen and Zovaber receive water from local groundwater sources. The drinking water supply network of the above mentioned communities has about 40% water loss due to the fact that it is outdated, degradation and needs renovation.

In the pilot river basin the return water from the drinking water supply annually compose about 14.9 million m^3 (34.4% of the water flow), and from industrial water supply the annual volume of return waters compose 5.4 million m^3 (about 44.3 % of the water flow). Thus, the total return water from the sectors compose 20.3 million m^3 (about of the water flow 36.6%).

In the pilot river basin the water discharge pipeline start from Sevan city and through a pipeline with a diameter of 1000 mm passes through Tsaghkunq, Ddmashen, Zovaber and Jrarat communities. The pipeline reaches Hrazdan city, where it is joined with the 400 mm diameter pipeline of Hanqavan-Hrazdan system. The water discharge pipeline in Hrazdan city continues with two pipeline collectors of 1000 mm diameter, which reach Qaghsi wastewater treatment facility. Currently the water discharge network is outdated, needs renovation and the network. Thus, in many sections the network is damaged, and as a result the industrial and communal wastewaters directly flow into the river, polluting the environment and degrading the quality of the lake. Due to damages in the sewerage pipeline after Hrazdan city and before Aghbyurak reservoir the wastewater from the entire basin flow into the river and do not reach the Qagshi wastewater treatment facility. It is interesting that the rivers act as the main receiving body of most of the return waters.

The water supply and discharge network for the urban settlements (Table 11) is also outdated and degrade, and over 50% of the network needs renovation (Table 11).

Table 11: Characteristics of the Urban Water Supply and Water Discharge Network in the Pilot River Basin

Settlements	Sewerage network			
	Internal networks of sewerage		Sewerage collector	
	Length (km)	Number of observation wells (pieces)	Length (km)	Number of observation wells (pieces)
City Hrazdan	352.5	2272	7.5	90
City Tsaghkadzor	4.52	26	31.9	93
City Sevan	66	1466	25	440

Settlements	Single-line length, km				Original capacity of the treatment facilities, thousand m^3/day	Wastewater discharges, total
	of the main collector	of the sewerage and street network	from which need renovation	of inter-district, inter-yard networks		
City Sevan	25.0	66.0	32.3	8.0	-	242.1
City Hrazdan	7.5	352.5	46.1	6.0	64.0	1079.1
City Tsaghkadzor	31.9	4.5	3.0	1.0	-	254.7

Figure 19: Water loss From Degraded Pipelines

For ***hydropower production purposes*** in the pilot river basin the following companies operate: "Tezh Waterfall", "Energatzantzshin" and "Hanqavan 1" small HPPs, which together annually abstract 50.9 million m^3 of water. In addition to this, using the waters of the Sevan-Hrazdan derivation regulatory canal Sevan and Atarbekyan HPPs operate (Table 12).

Table 12: Summary Characteristics of the Water Used for Hydro-energy Purposes in the Pilot River Basin

Object holding water use permit	Place of activity	Water abstraction sources and location	Quantity of annual abstraction, m^3	Location of wastewater discharge	Annual discharge of wastewater, m^3
"Energatzantzshin" JSC, small HPP	Hrazdan city of Kotayq marz	Surface, Marmarik River	29,980,000	Marmarik River	29,980,000
"Tezh Waterfall" LTD, small HPP	Meghradzor village of Kotayq marz	Surface, Tezh tributary of Meghradzor River	10,910,000	Tezh tributary of Meghradzor River	10,910,000

Object holding water use permit	Place of activity	Water abstraction sources and location	Quantity of annual abstraction, m^3	Location of wastewater discharge	Annual discharge of wastewater, m^3
"Hanqavan 1" small HPP	Hanqavan village of Kotayq marz	Surface, Miskhana tributary of Marmarik River	10,000,000	Surface, Miskhana tributary of Marmarik River	10,000,000
Sevan HPP	City Sevan of Gegharkunik marz	Sevan-Hrazdan derivation regulatory channel	150.000.000	Sevan-Hrazdan derivation regulatory channel	Sevan-Hrazdan derivation regulatory channel
Atarbekyan HPP	City Hrazdan of Kotayq marz	Sevan-Hrazdan derivation regulatory channel	150.000.000	Sevan-Hrazdan derivation regulatory channel	Sevan-Hrazdan derivation regulatory channel

"Tezh Waterfall" small HPP operates since 2007. It uses the free flow and produces electricity. The annual production volume is 4-5 million kWatt hour electricity. Annually 10,910,000 m^3 of water is being abstracted by the HPP, which is distributed evenly throughout the year.

"Energatzantzshin" JSC operates the "Narek" small HPP, which operates since 2002. The small HPP uses the free flow and produces electricity. It has been constructed on the water pipeline of the "Mika Cement" JSC. The small HPP operates on a seasonal basin, during the months March-July and October-November. The average monthly production volume of electricity composes 143,000 kWatt hours.

It is expected, that "Hanqavan" small HPP will start its operation in 2011. According to the technical design and characteristics, which are included in the water use permit conditions, the total annual volume of electricity production will compose 2,710,000 kWatt hours.

All small HPPs sell electricity at the price of 19.95 AMD/kWatt hours.

For ***irrigation purposes*** in the pilot river basin "Sevan-Hrazdan Jrar (water intake)" CJSC sells water to "Hrazdan Jur" Water Users Association (WUA). "Hrazdan Jur" WUA service communities, the total area of which composes 9210 ha. The total irrigated area in the upper Hrazdan River basin composes 3782 ha, of which homestead gardens 563 ha and irrigated arable lands - 2957 ha. The communities of Marmarik River basin do not use the services of "Hrazdan Jur" WUA and use water illegally. As for the communities Varser, Zovaber, Ddmashen, Geghamavan and Tsaghkunq, they use self-supplied irrigation water. Thus, the actual service area of "Hrazdan Jur" WUA composes 1652 ha.

About 1.64 million m^3 of water is being used for irrigation purposes in the territory, including water loss. Together with the permitted abstraction for irrigation purposes for other communities (950 thousand m^3) the total abstraction composes 2.59 million m_3 (1.64+0.95), from which no return water is expected (though according to calculations it could have compose about 20% of the water abstraction or about 0.5 million m^3).

"Hrazdan Jur" WUA purchases water from "Sevan-Hrazdan Jrar" CJSC at the price of 1.01 AMD/m^3. The total amount of water purchased is 5.2 million m^3 per year. Of this, annually only 3 million m^3 are actually delivered to consumers, which means that the annual water loss composes 42%.

Currently, the Marmarik River basin is not included in the service area of "Hrazdan Jur" WUA, since the population in these rural communities has refused to be included in the service area of the WUA.

There are several reasons for such attitude. First, due to improper compliance assurance activities in the basin the rural communities are able to use irrigation water illegally, and thus, not make any payment for the water they use. Secondly, public awareness on the advantages of joining WUA is still low and the main benefits are not properly communicated to the residents of Marmarik basin. Thirdly, "Hrazdan Jur" WUA itself is still a weak organization, is heavily dependent on state budget subsidies and it will take some time until the financial sustainability issues are solved.

Naturally, no proper metering of water used takes place. They illegally take water from the water pipeline of Hrazdan Cement Factory, mainly during summer seasons, which is technical water, taken for cooling and other technical purposes. Since there is no proper organization responsible for O&M of the irrigation system in Marmarik River basin, naturally the irrigation infrastructure is deteriorated, water losses are huge and water is not being used rationally. In addition, in case of high leakages and outbreaks, the repairs are being done chaotically and not in systematized manner. Eventually, according to some estimates the residents of the basin end up spending almost the same amount for water use, as they would if they joined the "Hrazdan WUA".

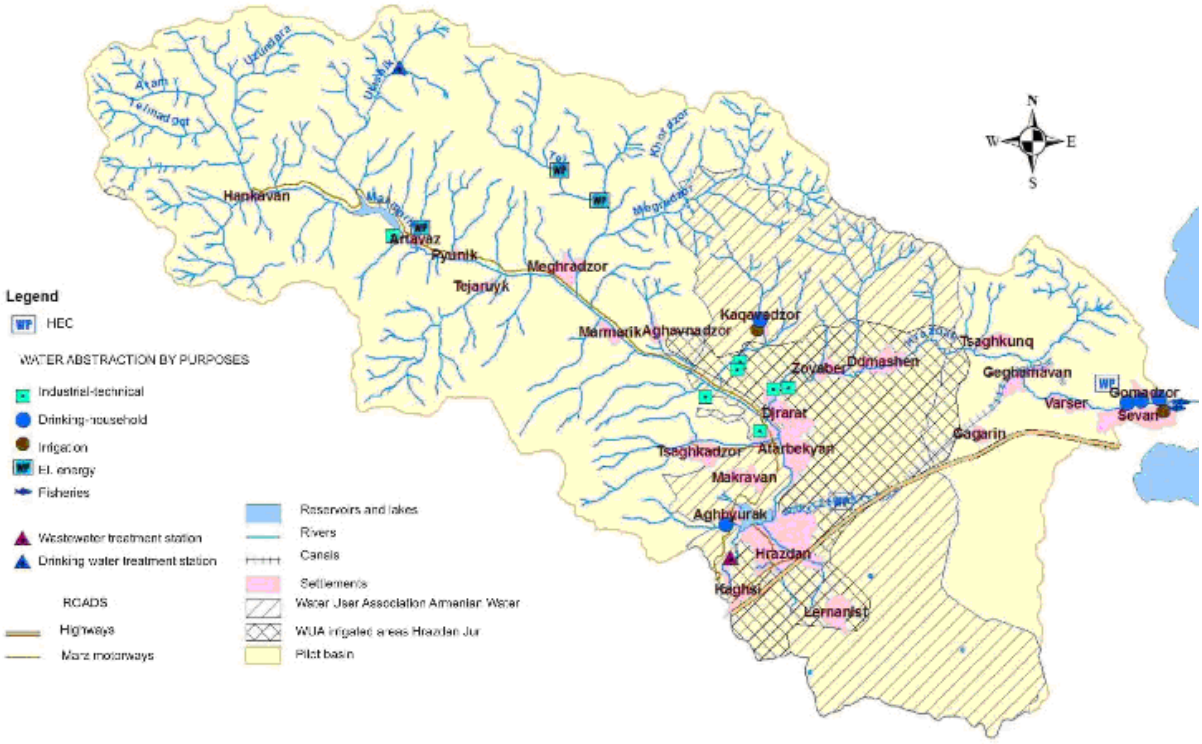


Figure 20: Water Use and Water Supply Service Areas

The following crops are produced in the irrigated areas of the pilot river basin: potato (45%), vegetable (28%), grain (20%), and gardens (7%).

For ***recreational purposes*** part of the resort houses in Hrazdan, Marmarik and Tsaghkadzor use self-supplied water instead of using the services of the AWSC. Currently 8 resort houses have drinking water use permits.

The total volume of the annual water abstraction in the pilot river basin without water abstraction for HPPs composes 58.1 million m^3 (55.5+2.6), and the annual volume of return waters is 20.8 million m^3 (20.3+0.5), which composes 35.8% of the total water abstraction. And if we take into consideration the accepted norm, according to which the return waters usually compose 75% of the total water abstraction, then in the pilot river basin the annual volume of return waters will compose 43.5 million m^3.

5. DIAGNOSTIC ANALYSIS

5.1. Water Quality

From the characterization and assessment of the water quality in pilot river basin it is clear that Hrazdan River:

- Mainly corresponds to the accepter norms for fisheries, industrial, irrigation and energetic water uses, The concentrations of total mineralization, anions and cations, as well as hardness are significantly decreased after the confluence with Marmarik River,
- Water quality is deteriorating, and this is particularly due to increase of concentration in nitrogen and phosphorous compounds in the water, particularly during the last 5-6 years,
- During the last 5-6 years an inflow of wastewater from communal-household, agricultural and livestock breeding sectors exists, which in parallel passes intensive aeration,
- During the last 5-6 years among the main factors of pressure also include the reduction of forest cover, which is contingent upon increased erosion, windstorms and soil washing.

The correlation of problems and risks identified in the analysis of Hrazdan River basin is presented in Table 13 below together with the interlinkage with the water use functions.

Table 13: The mutual linkage of the characteristics problems in the Hrazdan watershed (until the settlement Qaghsi) and the water use purpose functions

Problems*	Public health and socio-economic condition	Natural functioning of ecosystem	Fishing and small-scale fisheries	Tourism and recreation	Drinking and household water	Irrigation	Industry	Hydroenergy	Trends in the upcoming years
Water scarcity, seasonal	P	P	P	P		P	P	P	↑
Mudflows and flooding	P	P	P	P		P			risk
Strong wind	P	P		P	P			P	↑
Generation and collection of sediments	P	P		P	P	P		P	risk
Salinization		P			P	P	P		risk
Reduction of forest cover	P	P		P	P				↑
Pollution with organic substances	P	P	P	P	P				↑
Pollution with nitrogen and phosphorous substances	P	P	P	P	P	P	P		risk
Eutrophication	P	P	P	P	P	P			risk
P	**Existence of problem or risk**								
P	**Priority problems**								
↑	These problems might become acute, particularly parallel to development of economy, if no preventive measures are taken on time.								

Marmarik River

- For the use for fisheries, communal-household, drinking and irrigation purposes the water quality of Marmarik River is of good or excellent order,
- Marmarik River's waters are high quality water resources for the purposes of fisheries, drinking water and irrigation water,
- The concentration of nitrogen compounds is decreasing due to anthropogenic pressures, but however, continues to be rather high.

The correlation of problems and risks identified in the analysis of Marmarik River basin is presented in Table 14 below together with the interlinkage with the water use functions.

Table 14: Mutual linkage between the water use purpose functions and characteristic problems in Marmarik watershed

Problems *	Public health and socio-economic condition	Natural functioning of ecosystem	Fishing and small-scale fisheries	Tourism and recreation	Drinking and household water	Irrigation	Industry	Hydroenergy	Trends in the upcoming years
Water scarcity, seasonal	**P**		**P**	**P**		**P**	**P**	**P**	↑
Mudflows and flooding			**P**	**P**		**P**			**risk**
Strong wind	**P**	**P**		**P**	**P**			**P**	↑
Generation and collection of sediments	**P**	**P**		**P**	**P**			**P**	**risk**
Salinization		**P**			**P**	**P**	**P**		**risk**
Reduction of forest cover	**P**	**P**		**P**	**P**				↑
Pollution with organic substances	**P**	**P**	**P**	**P**	**P**				↑
Pollution with nitrogen and phosphorous substances	**P**	**P**	**P**	**P**	**P**	**P**	**P**		**risk**
Eutrophication	**P**	**P**	**P**	**P**	**P**	**P**			**risk**
P	**Existence of problems or risk**								
P	**Priority problems**								
↑	These problems might become acute, particularly parallel to development of economy, if no preventive measures are taken on time.								

Tsaraghbyur River

- The results obtained show that for the purposes of fisheries, communal-household, drinking and irrigation use the water quality in the upper and middle sections of Tsaraghbyur River is of good or excellent order. In the lower sections, in Tsaghkadzor city and downstream of city the river's water is subject to very large pressure from communal-household wastewater, which increases every year. In the territory of Tsaghkadzor city the river's water are subject to intensive pollution with nutrients, and as a result of which in the downstream sections the water quality poor or bad,
- In the entire basin an inflow of nitrogen, phosphorous and organic compounds into the rivers is observed through direct inflow or through diffused wasters.

Generalization of the current problems

- Limit such water use, that might increase the concentration of nitrogen compounds in the composition of the river's water,
- Construct and employ a wastewater treatment facility and renovate the sewerage collectors,
- Implement corresponding measures in the entire watershed to limit the inflow of nitrogen compounds into the rivers waters through direct inflow and through inflow from diffused sources,
- Establish a sewerage collector in Tsaghkadzor city and general wastewater treatment station or local wastewater treatment stations to tourist complexes, which will significantly reduce the concentration of nitrogen, phosphorous and organic compounds in river's waters.

The correlation of problems and risks identified in the analysis of Tsaraghbyur River basin is presented in Table 15 below together with the interlinkage with the water use functions.

Table 15: Mutual linkage between the water use purpose functions and characteristic problems in Tsaraghbyur watershed

Problems*	Public health and socio-economic condition	Natural functioning of ecosystem	Fishing and small-scale fisheries	Tourism and recreation	Drinking and household water	Irrigation	Industry	Hydroenergy	Trends in the upcoming years
Water scarcity, seasonal	**P**	**P**	**P**	**P**		**P**			**risk**
Mudflows and flooding	**P**	**P**	**P**	**P**		**P**			**risk**
Strong wind	**P**	**P**	**P**	**P**					↑
Generation and collection of sediments	**P**	**P**	**P**	**P**					**risk**
Salinization									
Reduction of forest cover	**P**	**P**		**P**					↑
Pollution with organic substances	**P**	**P**	**P**	**P**					↑
Pollution with nitrogen and phosphorous substances	**P**	**P**	**P**	**P**					↑
Eutrophhication	**P**	**P**	**P**	**P**		**P**			↑
Pollution with poisonous substances, metals and poisonous chemicals									
P	**Existence of problems or risk**								
P	**Priority problems**								
↑	These problems might become acute, particularly parallel to development of economy, if no preventive measures are taken on time.								

5.2. Water Quantity

The annual river flow in the pilot river basin composes about 243 million m^3, of which the total annual water abstraction composes 58 million m^3. Most of the river flow is occurring during the spring period. After exploitation of Marmarik reservoir the water deficit will reduce. However, there are still issues related to water quantity in the basin, including the following:

- There is a water scarcity during the low-flow summer season,
- In the irrigation system the water loss is huge and composes 45-60%,
- Hydro-energy resources of the basin are used insufficiently,
- The quality of service provision for drinking water is still low,
- Taking into consideration that on an annual basis there is excess water in the basin, there is a need to regulate the river flow,
- According to forecasts of climate change specialists, it is expected that the river flow in the river basin will decline by 5-24% in the period 2030-2100, which will make the issues related to water suppliers and water users more acute.

The priorities for solving the existing problems include the following:

- Regulation of river flow, including reservoir construction,
- Protection and efficient use of water resources,
- Protection and efficient use of drinking and mineral waters,
- Establishment of wastewater treatment facilities in the river basin,
- Construction of wastewater treatment stations in the large communities,
- Construction of local wastewater treatment facilities in the hotels and resort houses.

5.3. Erosion Processes

In the pilot river basin two types of erosion processes are observed - spatial and linear. Each year, particularly during the spring inundations, in Hrazdan and Marmarik Rivers bank erosion is observed. The bank erosion is very well reflected in the lower reaches of Marmarik and Gomur Rivers. As a result of erosion and flooding the Hrazdan River in Jrarat and Hrazdan communities, as well as Marmarik River, in the lower sections (Meghradzor and Aghavnadzor communities), cause significant damages to agricultural lands. The rivers destroy the banks and expand the river beds at the expense of the adjacent agricultural lands. In case of implementing bank-protection measures it will be possible to avoid erosion. This can be done through establishment of forest buffer-protective zone on the banks of the rivers, as well as construction of concrete walls in the bank.

Erosion processes are also observed in the deforested areas and in the clearings. Here in the high incline topographies one can observe well-reflected linear erosion during precipitations. Similar occurrences are observed in the high mountainous alpine and sub-alpine zones. As a result of improper grazing practices, fires (due to which the surface vegetation if destroyed) and irregular field roads the erosion processes are activated and intensified. In the upper Hrazdan pilot river basin the erosion processes are distributed in Pambak mountainous range, upper sections of Marmarik River basin, Ulashik and Gomur River basins, as well as in the upper zones of Taghkunq, Ddmashen and Zovaber communities. It will be possible to prevent erosion only through planned tending a herd, increased ecological education level among population, prohibition of irregular and illegal roads and other anti-erosion measures.

5.4. Deforestation

According to our studies and evaluation, in the territory of the pilot river basin about 180-200 ha of forests have been cut. The illegal forest felling continues even nowadays, but at a lesser scale. In addition to illegal felling, the forest cover is nowadays reduced as a result of extension of hotel complexes and restaurants (in Tsaghkadzor and Marmarik River basins).

Forests have a big role in regulation of water resources. Forests have a property of absorbing humidity. Reduction of forests violated the biodiversity of the forests, which has a negative impact on water ecosystem as well. In the forested territories near the settlements (Meghradzor, Artavaz, Aghavnadzor, Hanqavan) the anthropogenic impact of forests, illegal seizure of land areas, illegal forest cuts, illegal tending herd, pollution and damages to forest ecosystems and other activities are observed. As a result of such negative factors and activities the forest ecosystems are degraded. In addition to the above-mentioned negative factors, the climate changes specialists envisage 8-10% reduction of forest cover by 2100 as a result of global climate change, as well as shifting the upper zone of forests by 150-200 meters, at the expense of sub-alpine meadows. For grazing lands it is envisaged that the climate change will cause a 4-10% reduction of the total area and yield, including 19-22% reduction of the most valuable and high productivity pastures in the alpine and sub-alpine zones, as well as 7-10% reduction of yields of mountainous plough lands. In this regards a reduction of livestock number is expected by about 30%, as well as reduction of the output of livestock breeding by 28-33%.

For protection and efficient use of forest biodiversity and ecosystems it is necessary to implement the following:

- Prevent degradation of forest ecosystems which are damaged by the impact of negative factors, restore the forest resources in the previously forest-covered areas which are currently logged or deforested by some other reason, increase productivity of forests, and provide for protection of forest biodiversity, natural regeneration and extension of forest-covered territories,

- Implement payment for ecosystems scheme for use of biological resources of forests. Use of possibility to get benefit from forests, forest resources and natural useful properties of the forest lands.

5.5. Land Degradation

In the pilot river based as a result of reduction of forest cover the erosion and weathering have significantly increased, as a result of which soil layers are being degraded.

As we have already observed in section 5.3 due to improper cattle grazing practices, fires, irregular field roads erosion occurs, as a result of which a degradation of land in the form of weathering occurs.

As a result of improper land use it is impossible to avoid land degradation, which is expressed by washing of soil layer during irrigation of arable lands and others.

In the pilot river basins in many land areas one can observe large piles of municipal and industrial waste, which impact the products of land and prevent them from being ecologically clean.

Measures to prevent soil degradation include:

- Replacement of soil-processing practices and technologies with the ones of low risk to the extent possible,
- Establishment of a forest protection layers in the agricultural land zones of the watersheds,
- Establishment of a system for reduction and prevention of strong winds.

6. LEGAL FRAMEWORK FOR APPLICATION OF ECONOMIC INSTRUMENTS

6.1. Legislative Framework

The nature protection legislation is a system of normative legal acts, which regulate the public relations in the context of inter-relationship between the public and environment.

The environmental legislation includes normative legal acts on protection of fauna, flora, water resources, soils, underground resources, atmospheric air, on conducting environmental impact assessment, as well as other normative legal provisions and requirements.

These requirements are fixed in certain articles of the Constitution of the Republic of Armenia, codes, corresponding laws, Government of Armenia resolutions and other regulatory acts.

In the field of nature protection Armenia's policy is mainly formed taking into consideration the obligations according to international agreements. Thus, regulation of nature protection in Armenia started its formation in 1991, and as of today in total more than 30 codes and laws has been adopted together with corresponding by-laws and regulations, aimed to ensure the smooth implementation of the codes and laws. Parallel to development of the country's economy certain directions of environmental policy and environmental legal acts, which did not ensure the protection and sustainable use and management of natural resources as a result of economic activities, were subject to corresponding revisions. Particularly after 2000 six new codes and laws, adopted after 1990s were correspondingly revised.

This section analyzes the application of economic instruments in the field of environmental and water resources protection in Armenia.

The main laws regulating the natural resources, water norms and water relations are the following:

- Republic of Armenia “Water Code”, adopted by the RA National Assembly on June 4, 2002 and ratified by RA President on July 1, 2001;
- Republic of Armenia law “On Fundamental Provisions on the National Water Policy of the Republic of Armenia” adopted by RA National Assembly on May 3, 2005 and ratified by RA President on June 2, 2005;
- Republic of Armenia law “On National Water Program” adopted on November 27, 2006;
- Republic of Armenia law “On Lake Sevan”, adopted on May 15, 2001 and ratified by RA President on June 14, 2011.

The following legal acts contain legal provisions on ecosystems and water sector:

- RA Land Code (adopted on June 2, 2001);
- Republic of Armenia law "On Underground" (adopted on November 06, 2002);
- RA Forest Code (adopted on October 24, 2005);
- RA law "On Flora" (adopted on November 23, 1999);
- RA law "On Environmental Inspectorate" (adopted on April 11, 2005);
- RA law "On Nature Protection and Nature Use Fees" (adopted on December 28, 1998);
- RA law "On Rates of Nature Protection Fees" (adopted on December 20, 2006);
- RA law "On Defining Discount Rates for Drinking Water Supply, Discharge, Wastewater Treatment and Irrigation Water Supply Services" (adopted on November 06, 2002) subsequent revision and amendment (adopted on October 22, 2003);
- RA law "On Environmental Impact Expertise" (adopted on November 20, 1995);
- RA law “On Specially Protected Nature Areas” (adopted on November 27, 2006);

- RA law "On Approval of Tariffs for Compensation of Damage Caused to Flora and Fauna as a result of environmental Violations" (May 3, 2005).

The main legal act governing the water sector is the **Water Code**, and the other laws and by-laws are mainly implied from the Water Code. The Armenian Water Code includes almost all the issues regulating the legal norms and legal framework of water sector.

The Water Code provides opportunity for development of mechanisms and proposals on introduction of PES schemes in the context of integrated water resources management. The provisions of the Code provide a possibility to develop a legal framework for application of the PES. Ecosystem services can be valued through existing valuation methods in the country, including direct and alternative effects valuation. Ecosystem services are defined *according to the* ***positive difference of the economic assessment of the benefits of the ecosystem and costs for realization of the benefits.***

RA Water Code includes several provisions and principles, which are considered as basis for implementing legal and structural reforms. However, there is still lack of by laws, which will make it possible to fully employ economic management tools and instruments in IWRM, despite that fact that the Water Code includes corresponding provisions and principles of applying such tools.

Particularly chapter 11 of the Code discusses economic incentives and the system of payment in water relations. Article 76 of Chapter 11 provides for economic regulation principles for the use, restoration and protection of water resources, water supply and wastewater systems. Article 77 of the same Chapter defines the baseline for water use permit fees, which has not been applied since adoption of the code. Since the introduction of the Water Code in Armenia in 2002 the water use permit fees were aimed at developing a culture of paying for water abstraction and water wastewater discharged, but in reality this fees did not reflect the baselines for water use permit fee, as required by the Article 77 of the Code. Thus, Article 77 requires that the baseline for water use permit fee include the following:

- volume, quality and regime of water withdrawn from the water resources,
- volume of manufactures production, renders services, completed works that were performed without water intake from the water resource,
- use surface of the water resource,
- purposeful or non-purposeful use of the water resource based on the qualitative and quantitative water characteristics,
- volume and quality of wastewater discharges into the water.

From the above-mentioned criteria only that first and last ones are being applied at the moment, whereas for application of the other criteria there are no corresponding legal basis and mechanisms.

To increase water use efficiency and improve water quality, as well as to raise the interest of water users, the water use permit fees retained from individual water use permit holders can be different given such factors as:

- The quality of water withdrawn from and the discharged into the water resource in comparison with the quality of the water resource into which water is discharged, as well as the profit of the person holding water use permit,
- The costs of monitoring,
- The quantity of water withdrawn, and
- Possible impacts on the quality and quantity of the water and risks and restoration costs associated with it.

In addition to this, Article 5 of the Code described the basin principles of management, use and protection of water resources and water systems and as one of the basic principles includes that fact that there is no alternative to water, it has environmental and economic value not only in case

when it is used, but also when it is not used. According to another principle, the management of water resources shall be implemented through recognition of relationship of water and its adjacent ecosystems.

Republic of Armenia law "On Fundamental Provisions of the National Water Policy" is one of the most important laws, which was development and adopted after adoption of the Water Code, and which implies for the provisions of the Code. The law indicates the main objectives of the policy, principles for development of water policy and water management, formation of water demand and supply, priorities for water resources protection and use, implementation of water basin management as basis for strategic management of water resources, indicator assessment of emergency situations and priority for ensure proper water supply.

Republic of Armenia law "On National Water Program" includes provisions on usable water resources, strategic and national water reserves, classification of water resources and water systems, perspective issues, water resources management issues (monitoring, data management, resources planning, impact on water resources and water quality norms, provisions for definition of ecological situations and prevention of negative impact on water), fundamental principles for complex management of water supply and demand (ensuring accessibility, demand management), provisions for step-wise implementation of national water program and economic mechanisms.

Other codes and laws of Armenia (land, underground, forest) and laws regulating the legal relationship of natural resources use also contain legal provisions related to water sector.

Thus, the RA land code includes provisions on water lands, hydropower lands, communal lands related to water and lands for resort areas. Land servitudes include laying water supply pipelines and their operation.

The law "On Underground" includes legal norms of groundwater resources.

RA forest code includes provisions of classification of forests according to the purpose of their use. Among the classes, the sanitary forests, which serve as buffer sanitary zones for water protection and water supply sources are mentioned, including the possibility for establishment of water captation and implementation of hydro-meliorative measures in the territories of forests.

In the law "On Rates of Nature Protection Fees and Natural Resources Fees" a water resource use fee is envisaged.

6.2. Payments and Rates of Environmental Fees and Natural Resources Use Fees

The types of environmental fees include:

a) fees for emissions of hazardous materials into the environment (air and water basins),
b) fees for disposal of industrial and consumer waste into the environment according to set procedures,
c) fees for goods causing damage to the environment.

Types of natural resources use include:

a) for water use,
b) for abstraction and consumption of minerals,
c) for use of natural resources.

The rates and fees employed in the water sector are regulated according to the Government of Armenia resolutions. According to Government Decision N864 of December 30, 1998 and further

amendments introduced by Decisions N789 of August 29, 2001 and N122 of December 13, 2007, the fees for irrigation purposes compose

The rates of natural resources use applied in the water sector are defined according to RA Government Resolution No 864 of December 30, 1998, according to which the following fees are defined for water use for irrigation purposes:

Table 16: Rates of fees for natural resources use for irrigation water abstraction

Type of water resource	AMD/m^3
Surface water	0.0
Fresh groundwater suitable for drinking purposes	1.0
Fresh groundwater not suitable for drinking	0.0
Waters of Lake Sevan	0.2

Table 17: Irrigation water supply by "Vorogum Jrar (irrigation intake)" CJSC

No	Description	Tariff, AMD/m^3	In force
1	To Water Users Associations, Federations of Water Users Association and other water users within the service area (2007-№61A, 2008 №575A)		April 1, 2007
1.1	Tariff for gravity-fed irrigation water supply	1.01	
1.2	Tariff for pumped irrigation water supply	11.52	

As for the rates for water resources abstraction fees for other purposes, they are defined according to the Government Decision No. 864 on Rates of Natural Resources Use Fees, of December 30, 1988.

Table 18: Rates of natural resource use fees for drinking purposes

Type of water resource	AMD/m^3
Surface water (except Lake Sevan)	0.5
Fresh groundwater suitable for drinking purposes	1.0

Table 19: Rates of natural resource use fees for water abstraction paid by AWSC, YWSC and local self-governance authorities

Type of water resource	AMD/m^3
Surface water (except Lake Sevan)	0.25
Fresh groundwater suitable for drinking purposes	0.05

Table 20: Rates of natural resource use fees for industrial water abstraction

Type of water resource	Fee, AMD/m^3
Surface water	0.5
Fresh groundwater suitable for drinking purposes	1.0
Fresh groundwater not suitable for drinking purposes	1.0

The payments associated with discharging wastewater into the open water basin are regulated according to the Republic of Armenia law "On Nature Protection and Natural Resources Fees" and law "On Rates for Nature Protection Fees". According to the latter law the following charges per ton are applied for discharging pollutants and their compounds into the water basins:

Table 21: Rates of nature protection fees per ton of discharged pollutants and its compounds

No.	Types of pollutants and their compounds	Rate of the nature protection fee per 1 ton, in AMD
1.	Suspended Particles	5,300
2.	Ammonium Nitrogen	5,100
3.	Acetone	301,000
4.	Biological Oxygen Demand	18,400
5.	Oil Products	204,600
6.	Copper	1,023,900

No.	Types of pollutants and their compounds	Rate of the nature protection fee per 1 ton, in AMD
7.	Sulphates	100
8.	Zinc	1,023,000
9.	Chlorides	30
10.	Trivalent Chrome	153,400
11.	Total Phosphate	40,000
12.	Fluorine	511,500
13.	Pesticide	18,200
14.	Acetic acid	16,900
15.	Sulphur dioxide	16,900
16.	Detergents	102,300
17.	Metallic salts	511,500
18.	Cyan and cyanide compounds	511,500
19.	Phenols	1,023,900

According to Government Decision No. 864 on Rates of Nature Use Fees, of December 30, 1988, the hydropower sector is not required to pay abstraction fees. Such decision is made taking into consideration the priority to develop alternative sources of energy in the country.

Rates of fees (per ton) for disposal of industrial and consumption waste are defined at 0 AMD/ton for non-hazardous waste, and 48,000 AMD/ton for hazardous waste of the first class. In addition to this, fees for goods causing damage to environment, fees for natural resources use and fees for abstraction of mineral resources are defined as well.

According to RA law "On Rates of Nature Protection Fees" rates of fees (per ton) for disposal of industrial and consumption waste into the environment are defined within the following intervals: 0 AMD for non-hazardous mining waste, 48,000 AMD for hazardous waste of the first class. In addition to this, rates of fees are defined for import or production of goods, which cause damage to the environment.

RA Government Resolution No 864 of December 30, 1998 "On Rates of Natural Resources Fees" defines the rates of fees for using and for consumed or abstracted mineral resources.

7. PROPOSED PES SCHEME FOR THE PILOT RIVER BASIN

7.1. Proposed Approach

As already mentioned, the upper sub-basins of Hrazdan River basin have rich biodiversity, due to which the settlements, particularly the territories adjacent to water resources in those sub-basins have favourable climatic conditions, and are attractive for expanding the settlements areas and establishment and development of resort houses, sport complexes and other recreation zoned.

It seems that the Tsaghkadzor sub-basin of Hrazdan River basin is leading in this aspect, but it has a negative impact on the ecosystem of Tsaghkadzor.

Air monitoring data show that the ground layer of air in Tsaghkadzor is clean. The quality of soils and atmospheric precipitation is also not degraded.

During the recent three years (2008-2010) the water quality in Tsaghkadzor city and below it is continuously deteriorating. During that period particularly the concentrations of nitrogen and phosphorous have increased in rivers waters (particularly ammonium ion and total phosphorous), as well as organic pollutants, which exceed over 10-fold the norms for fisheries and the corresponding concentrations observed upstream of Tsaghkadzor city. At the same time the analysis shows that the pressure from communal-household wastewater on river's water increases parallel to increase of the number of resort houses and number of tourists. Thus, the increase of concentrations of the above-mentioned parameters in the section of Tsaghkadzor city and downstream of the city is due to inflow of communal-household wastewater from Tsaghkadzor city. Since Tsaghkadzor city does not have a wastewater treatment facility the sewage water from Tsaghkadzor city and downstream the city are directly discharged into the river without any treatment.

The results of water quality monitoring conducted during the recent months, as well as visual observations show that the negative impact on Tsaghkadzor River, and thus on the water ecosystem of Tsaghkadzor, is quite significant and dramatically increases during the summer and winter months, whet the flow in the river decreases, and the number of tourists increases.

During the above-mentioned months the 24 objects (resort houses, sport complexes, restaurants and leisure objects) located in the river banks operate in their full capacity (see Annex 1).

According to the most conservative calculation the water use of those objects composes 2600 m3/day, which has a negative impact on rivers ecology. Given that during the day the water use is distributed unevenly (about 60-70% of the total water use occurs at 8-10am and 8-10pm), the wastewater, without any treatment, is being discharged into the river in a volley. Unlike for proportional discharge (when the discharge is being conducted evenly), in case of the discharge in a volley the recipient water body is subject to more impact. For example, in case of the Biological Oxygen Demand (BOD), the negative impacts increase 50-fold and more. The impact is particularly large when the ration of the discharges of wastewater and recipient water body are close to 1. In case of Tsaghkadzor River the coefficient equals 0.6 (wastewater discharge is 30 litre/second and the river discharge is 50 litre/second).

Calculation

Economic damage cause to Tsaghkadzor River by BOD during the winter-summer months in case of wastewater discharge in a volley (for non-official use)

Volume of wastewater:
Q=0.030 m^3/second x 86,400 second x 182 days = 471.6 thousand m^3
BOD concentration in wastewater – 240 g/m^3
Mass of BOD discharged into river - T
T – 471600 x 240 = 113.2 ton

According to methodology, in case of discharge of 113.2 tons of BOD a damage of 27.8 thousand USD is caused to water resource.

(Source: "Methodology for Calculation of Damage Causes to Economy due to Pollution of Environment" approved in 1986 by the Minister of Finance of Armenian SSR and the Chairman of the State Committee for Environmental Protection; and Order for assessment of the impact on water resources due to economic activities, approved by Government of Armenia Resolution No 1110-N of August 14, 2003).

As it can be noticed the calculation relates only to economic damage caused to Tsaghkadzor River and only from BOD. Similarly, we can calculate the damage caused by each pollutant included in the wastewater, and as a result the total economic damage will be 2-3 times more.

As for the damage caused to water ecosystem, its magnitude is contingent upon the self-cleaning capacity of the river. The mutual inter-relationship of the terms "water resources use and protection norming", "ecological flow" and "maximum allowable discharge" allows to outline the self-cleaning capacity of the river through application of the existing methodology for calculation of the marginal allowable discharge.

Taking into consideration that the above-mentioned approaches are fixed in the RA water code, the RA Ministry of Nature Protection, taking into consideration the peculiarities of water resources due to geographical conditions of topography structures of Armenia, has development and approved according to Minster's decree a methodology "On calculation of marginal allowable concentrations of wastewaters discharged into water resources", which later on was registered and obtained a status of legal acts of obligatory application in the RA Ministry of Justice (March 11, 2004, No 10504043).

The methodology is based on the studies of corresponding specialized organizations of the former USSR, including Armenian SSR. The methodology of calculation is based on the self-cleaning capacity of the water resources, based on which the extent of marginal allowable discharge of pollutants is defined.

As the studies in the field show, the main pressures on Tsaghkadzor River are from the resort houses, hotels, restaurants and other objects located on the banks of the river, as a result of activities of which mainly economic fecal, biological pollutant wastewater is generated. The main parameter of that type of wastewater pollution is the BOD, the concentration of which in similar wastewater composes about 240 mg/l.

According to studies the average daily flow of Tsaghkadzor River composes 0.050 m^3/second, whereas the average daily flow of wastewater composes 0.030 m3/second. Using this data and above-mentioned methodology we will get the value of the marginal allowable concentration of BOD5, which is equal to 7.24 mg/l (Annex 2).

As a matter of fact, in the giver section of wastewater discharge Tsaghkadzor River has such self-cleaning capacity, that reduces the impact of wastewater (BOD = 7.24 mg/l) down to allowable level 500 m downstream of the point of mixture.

For all rivers of Armenia, contingent upon the class according to concentrations of hazardous substances, marginal allowable values are defined. In the case of the observed section of Tsaghkadzor River the allowable value for BOD is 5 mg/l.

7.2. The Extent of Application of PES and Proposed Rates

According to the Republic of Armenia law "On Nature Protection and Natural Resources Use Fees" a certain rate is defined for each pollutant, which is being discharged into the water resources. For BOD the fee is 18,300 AMD/ton.

RA law "On Fundamental Provisions of the National Water Policy" fixed the principle "supply forms the demand", which as a matter of fact shall regulate natural resources use (wastewater discharge into water resource is also considered natural resources use, since for that purpose nature is used) to the extent, suggested or allowed by nature. Such regulation shall be done in an ecologically justifiable, logical and legal manner.

Thus, the rates for natural resource use and nature protection fees shall be applied to the volumes and masses, whose impact will not go beyond the violation of marginal allowable concentration of the ecological equilibrium of the ecosystem. In terms of water use, that water abstraction volume shall not reduce the ecological flow of the given section, and in terms of wastewater discharge the mass of pollutants discharged into the wastewater shall not be more, than the self-cleaning capacity of the water resource, required for preventing of the negative impact of the given material.

Summarizing the above-mentioned judgments, we can conclude that the acceptable rate of nature protection fee for BOD before the discharge into the water resource against the marginal allowable concentration will be MAV=7.24 g/m3.

Thus, since the organic pollution above 7.24 g/m3 discharged into Tsaghkadzor River is not subject to self-cleaning and has a significant negative impact on ecosystem. Thus, for any discharge above the MAV concentrations, as special, higher rate of fee shall be introduced as payment for ecosystem services (PES).

For introduction of PES rates the principle polluter pay has been applied, which is fixed in the Armenian water Code, together with the principle that the polluter shall cover the financial costs required to provide for pollution prevention and elimination measures.

Thus, as a result of logical interpretation of several above-mentioned principles of the RA Water Code, it became possible to define the baseline lower value for calculating the PES for causing irreversible damage to natural functioning of water ecosystems.

At the same time it is logical that the application of PES shall include the interval from the lower value up to the actual pollution level. In our case, for BOD, it composes from 7.24 m/m3 up to 240 g/m3, where 7.24 g/m3 is the lower value of PES, and 240 g/m3 is the actual concentration of BOD in the wastewater discharged into Tsaghkadzor River.

For application of PES it is necessary to define also a fee rate for unit of pollution. Taking into consideration the principle that "the polluter shall cover the financial costs associated to compensation of pollution" it is necessary to economically assess the costs associated to anthropogenic organic pollution of Tsaghkadzor River.

The number of population causing anthropogenic pressure on Tsaghkadzor River is 3,800, of which 1,800 is the permanent population, and 2,000 is temporary population (resort houses, sport complexes, restaurants and other).

According to preliminary estimates for construction of wastewater treatment facility with capacity of 3800 PE it will be required to invest 250,000 euro or 5 thousand euro annually within 50 years of lifetime.

Taking into consideration the concept of the PES, it will be logical to set rate for unit of pollution (for BOD) as the ratio of financial resources required for construction of wastewater treatment facility (250 thousand euro) and PES application interval (240-7.24=232.76 g/m3) times BOD mass included in 0.030 m3/second of wastewater during the summer-winter polluted period:

$$PES_{rate} = \frac{5000 \text{ euro}}{232.7 \text{ g/m}^3 \times 0.30 \text{ m}^3\text{/second} \times (180 \times 86.400)}$$

where 180 x 86400 is the number of second in the summer-winter period, and equals to 15.552 million.

$$PES_{rate} = \frac{5000}{108568512} = 0.000046 \text{ euro/gram.}$$

Thus, the PES rate for the objects adjacent to Tsaghkadzor River equals to 0.000046 euro per 1 gram of BOD discharged, which shall be applied towards only those objects, which is 2000 temporary visitors, for the benefit of 1800 permanent population. This can be done through establishment of special development fund under the jurisdiction of Tsaghkadzor community with condition, that the resources of this special fund shall be used for financing targeted measures towards reduction of pollution of Tsaghkadzor River.

The PES calculation provided below is for sample resort house:

> Period of activity: summer-winter t – 180 days
> Quantity of wastewater: q – 0.005 m3/second
> BOD concentration: L – 240 g/m3
> Lower value of application of PES: Lmin = 7.24 g/m3
> PES rate: e – 0.0921 euro/g
> ES = 180 x 86400 second x 0.005 m3/second x (240-7.24) g/m3 x 0.000046 euro/g = = 15552000 x 0.005 x 232.76 x 0.000046 = 0.83 thousand euro or 415.0 thousand AMD.

7.3. Next Steps

In order to apply the above-proposed principles it will be necessary to make revisions and additions in the current laws of the country, and/or develop new legal acts.

In case of fundamental solution of the above-mentioned subject it is preferable to have a separate and new Republic of Armenia law "On Payment for Ecosystem Services", which will defined the following:

- subject of regulation of the law,
- main concepts, including the concepts of ecosystem services, payment for ecosystem services, rate of payments for ecosystem services and so on,
- **payers** of the payments for ecosystem services,
- **types** of the payments for ecosystem services,
- **rates** of the payments for ecosystem services,
- **procedures for calculation and making payments** of the payments for ecosystem services,
- **timelines for presenting the calculations and making payments** for PES
- **procedures for calculating the actual size** of the PES,
- **currency of the payment** in PES scheme,
- **procedures for registration that payments, and paying back the excess payments** in PES schemes,

- **rights and obligations of the payers** of PES,
- **privileges** of the PES schemes,
- **responsibility in case of violation of the law**,
- **control** over the process of calculation of payments and actual payments in the PES scheme,
- transitional provisions.

With the adoption of the law it will be necessary to make corresponding adjustments, revisions and additions in the Republic of Armenia law "On Nature Protection and Nature Use Fees", and Republic of Armenia law "On Rates of Nature Protection Fees".

Partial solution of the problem can be achieved through inclusion of the proposed provisions of the Republic of Armenia law "On Payments for Ecosystem Services" into the Republic of Armenia law "On Nature Protection and Nature Use Fees" with a condition that PES is considered as a new type of environmental fee.

For the proposed both options it is necessary to solve the issues related to targeted use of money from applying PES on resort houses, hotels and other complexes.

Another option for solving the issue is introduction of a system of financing the impacted communities according to the Republic of Armenia law "On Targeted Use of Environmental Fees Paid by Organizations", when the environmental fees paid by polluting organizations are targeted towards implementing environmental or health related projects in the impacted communities.