CHAPTER 4

Emerging Challenges to IWRM

Strengthening Monitoring of Water Quantity and Quality

Key Messages

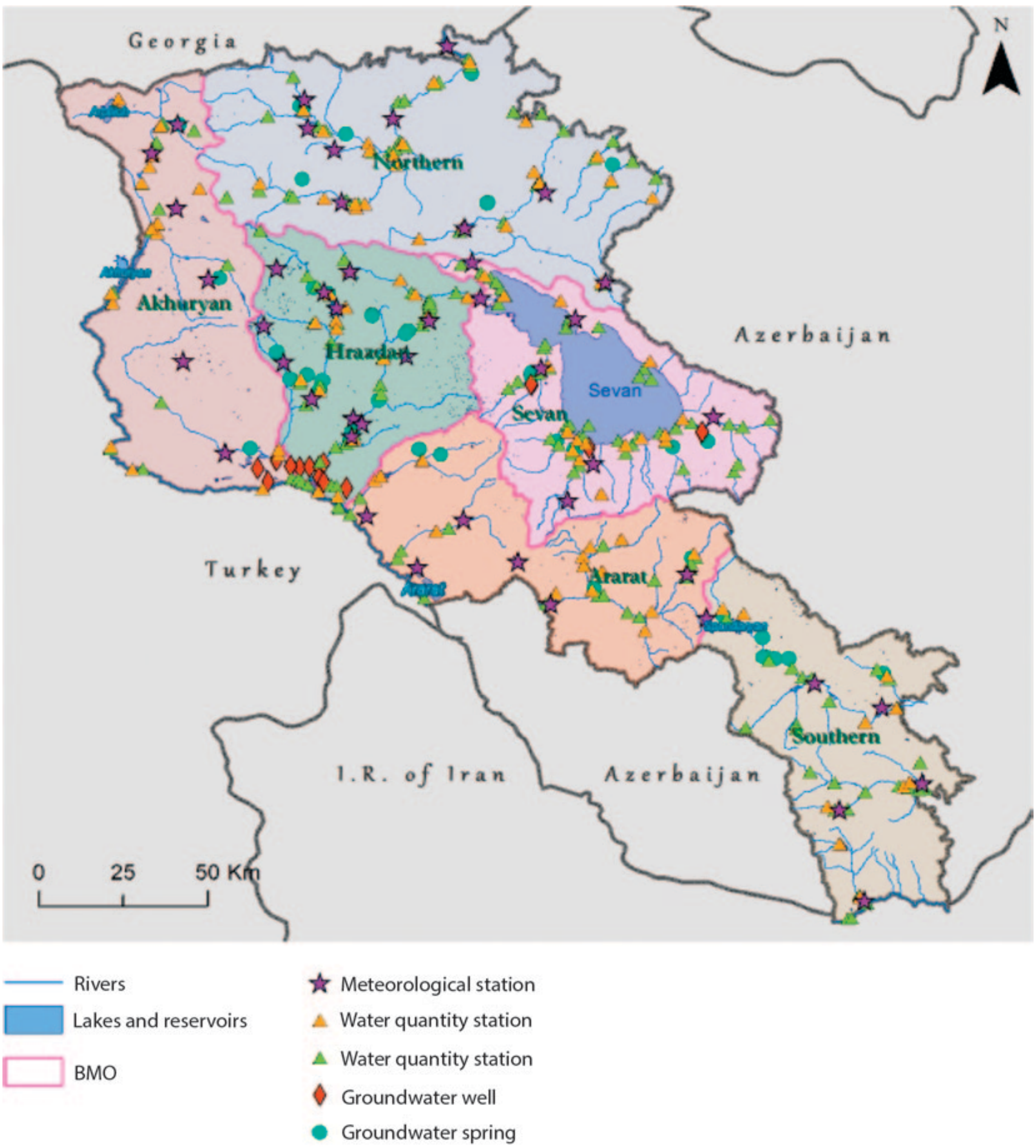
- Obtaining reliable, timely, good-quality, and publicly available data on water quantity and quality are precursors to a functioning integrated water management and planning system.
- Monitoring systems are vital to various planning and investment exercises, including in the issuance and compliance of water use permits (WUPs).
- Insufficient investment over decades in the monitoring infrastructure (including institutional capacity building) is evident, with opportunities to introduce new technologies and approaches to data collection, verification, and management.
- Improved coordination and harmonization across the various departments responsible for monitoring will be critical.

Introduction

Obtaining hydrometeorological information and data that are reliable, timely, of good quality, and publicly available is an essential precursor to good integrated water management and planning. Future investments cannot be fully prepared without a sufficient knowledge base on water resources in place. Moreover, day-to-day operations of the various water systems both for productive purposes (for example, irrigation, urban supply, environmental flows) and risk mitigation purposes (for example, flood warning) cannot be optimized without a robust near real-time monitoring network. Finally, management of the overall resource sustainability (for example, through permitting) and various competing pressures is only possible when data are being monitored over time and resource assessments updated regularly. In Armenia, there are several different agencies with responsibility for water monitoring (both quantity and quality, both surface water and groundwater). These include the State Environmental Inspectorate (SEI), the Hydrogeological Monitoring Center, the Environmental Impact Monitoring Center, and the ASHMS. Though duplication of efforts may not necessarily be inefficient, some rationalization and modernization is needed. Map 4.1 shows the locations of the water monitoring stations in Armenia.

Since Soviet days, very little investment has been devoted to strengthening the monitoring infrastructure. To enhance the current monitoring system, a comprehensive view must be taken. Over the last decade, investments in monitoring have been done in a piecemeal manner (a piece of equipment here, a piece of

Map 4.1 Water Monitoring Stations in Armenia



Source: USAID 2008.
Note: A full-color version of this map may be viewed at http://www.issuu.com/world.bank.publications/docs/9781464803352.

equipment there) with financing from outside donors. In most cases, the numbers of monitoring points could be expanded and the technologies used modernized (for example, through greater use of automated readers or real-time telemetry). Moreover, the quality of the monitoring infrastructure is poor and in many cases outdated (photo 4.1). Sharing of data among different agencies and access to

Photo 4.1 Pictures of Hydrological Monitoring Equipment

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data by the public (through department websites) also remains very limited. It is generally accepted that such investments are highly economical. A study conducted by the World Bank (2006) examining the economic efficiency of investments in hydrometeorological services in Armenia revealed that an estimated US$19 in prevented losses (from hydrometeorological hazards) could be achieved for every US$1 spent.

A driving force in introducing standards and protocols for monitoring is with respect to the European Union Water Framework Directive (see appendix E). Under the Water Framework Directive, three areas of monitoring are required. First, surveillance monitoring is needed from a fixed system to identify long-term changes and trends and to inform future monitoring networks; second, operational monitoring is needed to help classify and observe identified water bodies that are at risk of failing to meet various objectives; and third, investigative monitoring is needed whereby particular problems and challenges are studied in depth.

Current Institutions Responsible for Water Monitoring and Status

Table 4.1 shows the institutions responsible for water monitoring in Armenia.

State Environmental Inspectorate (SEI). Though substantial progress has been made in terms of putting a water use permit (WUP) system in place, compliance and enforcement of these permits remain weak. The Ministry of Nature Protection designated the SEI responsible for the enforcement of WUP requirements. The SEI monitors the following: actual water extraction points or water supply systems (name and location); actual extracted water quantities (total, by quarters of the year and allowed by the permit); quantity of water actually used for various needs (drinking, municipal, irrigation, industry, rural supply, and other); quantity of actual water returned (total, returned to surface waters, quantity of polluted water, quantity of wastewater treated by mechanical, physical-chemical, and biological methods); description of the outflow, including volume of hazardous chemicals in the water used and returned (actual and maximum allowed discharge); content of harmful substances in wastewater discharged to water resources by basins, marzes (provinces), and communities (including total biological oxygen demand, ammonia nitrogen, nitrates, nitrites, phosphates, chlorides, sulfates, iron, copper, zinc, nickel, suspended substances); and wastewater discharge to water resources, categorized by basins, marzes, and communities. This information is collected and submitted by hard copy to the SEI regional offices. In order to determine the amounts of constituents that are

Table 4.1 Water Monitoring Institutions in Armenia

Monitoring function	*Responsible agency*	*Ministry*
Surface water quantity	ASHMS	Emergency situations
Surface water quality	Environmental Impact Monitoring Center	Nature protection
Groundwater quantity and quality	Hydrogeological Monitoring Center	Nature protection
Drinking water sources and quality	State Health Inspectorate	Health care
Water use and pollution discharge	State Environmental Inspectorate	Nature protection

being discharged to a water body and determine compliance, water samples are collected at source and analyzed. However, sampling and inspection is performed only once a year for prioritized sources and even less often for nonprioritized sources. Due to a number of factors (such as shortage of equipment), the inspection and sampling frequency is inadequate (UNECE 2010). Box 4.1 shows the structural and territorial units of the SEI.

Hydrogeological Monitoring Center. In general, the state of groundwater monitoring (both quantity and quality) is weak. Following Armenian independence in 1993, the Soviet Union Hydrogeological Expedition (of the then Geological Department) was closed and groundwater monitoring ceased. By 2006 the National Water Program reestablished a Groundwater Monitoring Program highlighting the priority given to the establishment and operation of a national reference monitoring network. With the support of the United States Agency for International Development (USAID) Water Program around this time, the existing groundwater monitoring points were reestablished and various assessments undertaken. Moreover, 73 monitoring points were identified for the reference network, including 49 natural springs, 22 borehole wells, and 2 groundwater wells. USAID support was provided to rehabilitate 69 of these 73 monitoring points. These were handed over to the Hydrogeological Monitoring Center in 2008. The observed parameters at the monitoring points include temperature, water level, and discharge.

Given the importance of groundwater (especially for drinking water purposes), a more robust monitoring network is required. Very few long-term time series data exist (some old records exist that have yet to be digitized). This would be critical in identifying trends across various aquifer subunits. Moreover, few pump tests (essential for estimating basic aquifer parameters such as hydraulic conductivity, storativity, or effective porosity) have been completed for the different stratigraphy layers. There is also currently no equipment for

Box 4.1 Units of SEI

A. Structural units of SEI

- Division of Water Resources Supervision
- Division of Atmospheric Air Supervision
- Division of Biodiversity, Soils, Wastes, and Hazardous Substances Supervision
- Division of Entrails and Surveyor Supervision
- Division of Forests Supervision
- Central Laboratory

B. Territorial units of SEI

- Yerevan Territorial Division
- Syunik Territorial Division
- Ararat Territorial Division
- Armavir Territorial Division
- Aragatsotn Territorial Division
- Gegharkunik Territorial Division
- Kotayk Territorial Davison
- Tavush Territorial Division
- Lori Territorial Division
- Shirak Territorial Division
- Vayots Dzor Territorial Division

automated monitoring of groundwater levels. Data collected are reported in simple text formats. There is no standardized data archiving, treatment and analysis software, or procedure established. With respect to groundwater quality, the Hydrogeological Monitoring Center collects the groundwater samples but outsources the laboratory analysis to the Environmental Impact Monitoring Center or to the Geological Laboratory under the Ministry of Energy, as the Hydrogeological Monitoring Center does not have its own laboratory. The center measures some major ions with some overlapping analysis done by the Environmental Impact Monitoring Center. These elements can only provide the basic characterization of the origin of groundwater and a gross indicator of pollution (not persistent pollutants). No multiparameter probes are available with the department.

Environmental Impact Monitoring Center.[1] This department is responsible for the collection of surface water quality data. The central office is in Yerevan, where the main laboratory is housed. Two regional offices exist at Vanadzor and Kapan. Staffing is about 52 people. After 1992 water quality monitoring was drastically reduced, making long-term time series data unavailable. In 1998, only 55 water samples were taken. State budgets have improved from 13 million Armenian drams (AMD) (US$32,000) in 2004 to 70 million AMD (US$170,000) in 2013. Moreover, with support from various donors (especially USAID and the European Union), modern laboratory equipment has been provided (including mass spectrometers and chromatographs). Since 2007, the Environmental Impact Monitoring Center has been in full operation, with 1,200 samples gathered from 131 observation posts (6–12 samples per year). At these posts, about 50 variables are measured. This includes pH, biological oxygen demand, chemical oxygen demand, conductivity, major ions, and some metals. Analysis is being conducted according to ISO standards or other international standards. The Environmental Impact Monitoring Center also has a specific procedure for data verification and validation. The center publishes monthly and annual printed bulletins in the Armenian language, which contain data on surface water quality.

Armenian State Hydrometeorological and Monitoring Service (ASHMS).[2] This department is the main authorized body for surface water quantity and meteorological monitoring in the country. The department is under the Ministry of Emergency Situations. The total staff is around 592, of which 382 have university education. The department currently operates and maintains 47 meteorological stations (including 6 high-altitude stations and 3 specialized stations), 2 agrometeorological stations, 7 hydrological stations, and 94 hydrological observation posts. Though, in general, the density of stations may be adequate, the majority of the hydrological and meteorological observation points are poorly equipped. More snowpack measurements are needed. All of the hydrological observations are using simple water level rulers affixed to a local structure (locations shown in photo 4.1). The data are collected at each point twice a day. At a small number of these points (7 out of 94) flow meters are used to record actual discharges. About 30 observations annually are made using flow meters. Few observation points have some kind of automation. More than 80 percent of the hydrological stations were installed before 1970. With the data collected from all observation posts, the ASHMS headquarters in Yerevan processes the obtained data and prepares annual reference books. All data are being stored in an electronic database, which is not available online.

In general, the implementation of these hydrometeorological monitoring programs has been hampered by low salaries, little capital investment, and low operational budgets. As of 2014, the budgets for the ASHMS were as presented in table 4.2. Within these budget constraints, measurements such as snowpack, sediments in reservoirs and lakes, cross-sectional surveys, and water turbidity have been curtailed. Also, taking into consideration the move toward a river basin management approach, the network may need to be reevaluated and observation points placed at critical points in the basins.

One critical function of the ASHMS is with respect to forecasting. This is critical for water management both in the short term (in the case of flooding or droughts) and in the longer term (for seasonal agriculture planning, for example). The current capacity of forecasts, which is very much dependent on the quality of the monitoring, is given in table 4.3.

State Water Cadastre Information System (SWCIS). The SWCIS was developed as a supporting tool for integrated water resources management (IWRM)

Table 4.2 Budget Indicators for ASHMS in Armenia in 2014

Budget categories	*Expenditures as a percentage of budget*
Total budget	**763 million AMD (US$1.84 million)**
For meteorological monitoring (47 meteorological stations)	450 million AMD (US$1.08 million); 59%
For hydrological monitoring (94 hydrological observation posts)	156 million AMD (US$0.38 million); 20%
For other activities (hydrogeophysical monitoring, scientific research, etc.)	157 million AMD (US$0.38 million); 21%

Source: ASHMS.
Note: AMD = Armenian drams.

Table 4.3 Forecasting Capacity of ASHMS

Time frame	*Period/accuracy*
Lead time of standard forecasts:	
Short range	4–5 days
Mid range	7–15 days
Long range	1 month and more
Lead time of household warnings (hours)	1–12 hours
Accuracy of forecasts and warnings:	
Short range	80–85%
Mid range	71–76%
Long range	65–70%

Source: ASHMS.

for the Water Resources Management Agency (WRMA). The Water Code defines this system as "a permanent operating system to keep comprehensive records of quantitative and qualitative indices on water resources, water intakes, watersheds, composition and quantities of materials and biological resources, as well as records of water users, WUPs, and water system use permits." Thus, this system aims to integrate all databases into a single framework to be accessed by a range of stakeholders (table 4.4).

The WRMA is in charge of consolidation and maintenance of all water resources and water system-related information in this official repository. The SWCIS consists of a centralized data warehouse, operated and maintained by the Water Resources Monitoring and Cadastre Division of the WRMA, that stores national-level water resources data (tabular and spatial) with customized applications capable of analyzing and processing the data, and database applications at stakeholder institutions with customized export tools for transferring data from each database to the data warehouse. Access to these water resources data via the Internet and for broader public consumption is not possible because the WRMA website has been down since 2008.

Conclusions

Though a network of surface water and groundwater monitoring exists (table 4.5), additional investment is needed to ensure adequate future IWRM planning. Some clear gaps are observed (on a case-by-case basis) with each agency. For instance, strengthened groundwater monitoring that involves improving the understanding of the various aquifer layers and changes over time is needed. Also, as per the European Union Water Framework Directive, more will need to be

Table 4.4 Stakeholder Institutions of the SWCIS and Available Data

Stakeholder institution	*Available data*
WRMA, Ministry of Nature Protection (authorized agency for State Water Cadastre)	Water use and wastewater discharge data
ASHMS, Ministry of Emergency Situations	Surface water quantity data
Environmental Impact Monitoring Center, Ministry of Nature Protection	Surface water quality data
SEI, Ministry of Nature Protection	Actual water use and wastewater discharge data
Republican Geological Fund of the Geological Agency, Ministry of Energy and Natural Resources	Inventory of groundwater resources
Hydrogeological Monitoring Center, Ministry of Nature Protection	Groundwater quality and quantity data
State Committee on Water Systems under the Ministry of Territorial Administration	Water systems used for drinking water supply, irrigation water intake, drainage structure-operating organizations, and water user associations
State Inspectorate, Ministry of Health	Drinking water quality monitoring, water monitoring of open reservoirs, violations of sanitary norms

Source: European Union 2011.

Table 4.5 Summary Information on Surface Water and Groundwater Monitoring Points

Basin	*Area (km²)*	*Surface water quantity gauging stations: no.*	*Surface water quantity gauging stations: km² for 1 station*	*Surface water quality sampling points: no.*	*Surface water quality sampling points: km² for 1 station*	*Groundwater springs and wells*
Akhuryan	5,044	17	297	14	360	14
Ararat	4,460	13	319	16	279	8
Northern	7,068	23	307	25	283	39
Sevan	4,806	14	339	22	216	3
Hrazdan	3,881	16	243	33	118	1
Southern	4,484	9	498	21	213	8
Total	**29,743**	**92**	**334**	**131**	**245**	**73**

Source: European Union 2011.

done with respect to water quality, including enhancing hydrobiological monitoring and monitoring of the directive's pollutant priorities. In many cases, equipment could also be modernized with greater automation and real-time monitoring added. This may include the use of integrated monitoring approaches such as joint water quantity and quality stations. A more comprehensive strategic analysis of the monitoring requirements of the country and the capacity requirements to maintain such systems is needed. Though the SWCIS is meant to comprehensively consolidate this information and make it available online for a broad audience, this has yet to be achieved. Further strengthening of data-sharing mechanisms, particularly between the ASHMS and the WRMA, would be helpful. Overall, improved coordination and harmonization of surface water and groundwater quantity and quality monitoring activities will be critical.

Weakness in River Basin Management Planning

Key Messages

Despite the various initiatives supported by the donor community, the water sector in Armenia still faces many challenges in terms of river basin management planning.

- Needed skills and data to carry out modeling and planning work are not adequately available within the basin management organizations (BMOs).
- The current river basin planning template relies heavily on the European Union Water Framework Directive and focuses primarily on achieving good ecological status of water bodies.
- Broader intersectoral planning that takes into account municipal, agriculture, energy, and environment linkages and the various departments responsible is not sufficient.
- Completed river basin management plans (RBMPs) have yet to be adopted by the government. Government endorsement of such plans is needed to ensure

that all levels of government have a consistent planning vision and a clear prioritization of future investments.
- Analysis and knowledge on what would be the best allocation (both in economic and efficiency terms) for the different water users in the basin is needed.
- Lack of State-level budget is likely to undermine ongoing planning efforts and the full participation of BMOs in river basin planning.

Introduction

According to the Water Code, basin management authorities are called upon to develop river basin management plans (RBMPs). The RBMP is a comprehensive document that describes the management and conservation activities to be implemented within a river basin in order to achieve the objectives laid out in the Water Code. In line with international best practice, the Water Code strongly supports water resources (both surface water and groundwater) planning to be done at the level of the basin. Moreover, the Water Code highlights that RBMPs need to give sufficient attention to intersectoral balance among community, irrigation, energy, industry, and ecological uses. RBMPs are to be developed with the full participation of stakeholders.

The 2006 National Water Program included specific provisions for the development of these plans. Development and implementation of RBMPs will be an essential guiding framework for the basin management organizations (BMOs). Already several draft RBMPs have been developed or are in the process of development (Debed, Aghstev, Marmarik, Vorotan, Meghriget, Arpa, Akhuryan, Metsamor river basins). The government has yet to officially adopt, fund, or implement any of these plans.

Recent Water Resources Planning Efforts

Various river basin planning efforts have been completed or have been ongoing since 2007 (USAID 2012b). Following the requirements established in the Water Code, a model guideline for the formulation of the RBMP was developed in 2008 with the support of USAID. The model guideline was based on the principles of IWRM and the provisions of the European Union Water Framework Directive (box 4.2).

As shown in table 4.6, all of these RBMP efforts have been undertaken with the financial support of the donor community. In terms of coverage, almost all river basin management areas of Armenia have been covered. Map 4.2 indicates the geographic coverage of the completed or ongoing RBMPs and respective donors. None of the plans has been approved by government, and therefore they have no binding legal basis. Government endorsement of such plans is needed to ensure that all levels of government have a consistent planning vision and a clear prioritization of future investments.

The results of these early planning efforts (2008–10) have certainly provided valuable lessons and information for water resources planning in Armenia. Moreover, given the need to adopt further the existing model guideline to local conditions, in 2011 a protocol describing the elements that should

Box 4.2 RBMPs under the European Union Water Framework Directive

The European Union Water Framework Directive establishes that each member country has to produce and publish river basin management plans (RBMPs) by 2009 for each river basin district, including the designation of heavily modified water bodies, while encouraging the active involvement of all interested parties in their development and implementation. According to the directive, the RBMP is primarily intended to record the current status of water bodies within the river basin district; set out, in broad terms, what measures are planned to meet environmental objectives; and represent the main reporting mechanism to the European Commission and to the public. The plan should also summarize how the objectives set for the river basin (ecological status, quantitative status, chemical status, and protected area objectives) will be reached within the time scale required.

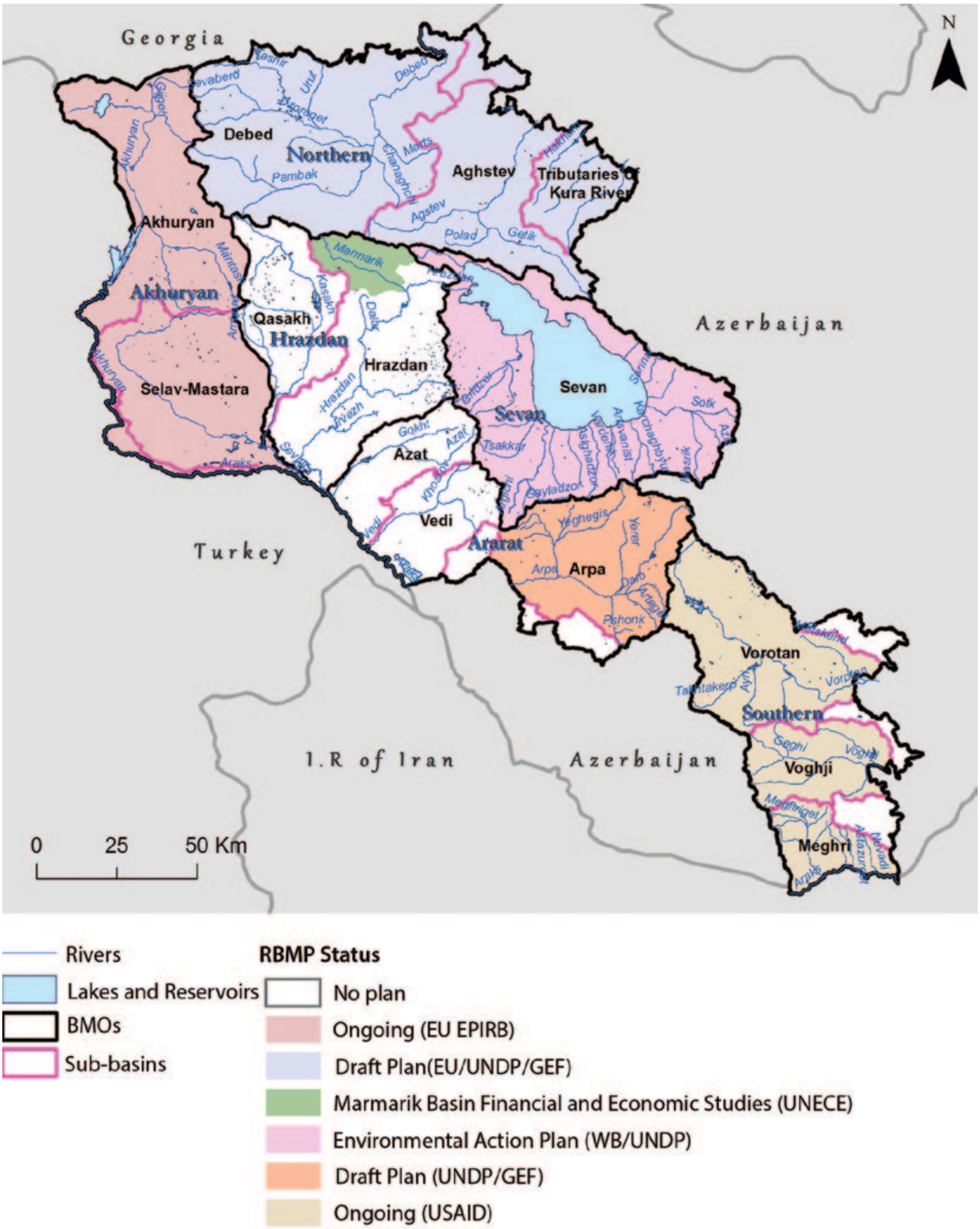
Table 4.6 River Basin Planning Efforts between 2008 and Present

Date completed	*Financial support*	*River basin management area and status*
2008	USAID	Application of the model guideline to the Meghriget River and its tributaries following into the Araks River.
2010	UNECE	Baseline conditions for and pressures facing IWRM in the Marmarik River basin, setting desired conditions for water uses and functions, and identification of measures to achieve desired conditions.
2010	European Union	Formulation of draft RBMPs for Aghstev and Debed Rivers based on Water Framework Directive requirements, and identification of water bodies at risk in terms of their ecological status and potential restoration measures.
2013	UNDP/GEF	Arpa RBMP being developed within the framework of the UNDP/GEF Reducing Transboundary Degradation in the Kura-Araks River Basin Project.
In progress	USAID	RBMPs for the Southern basin management area, comprising the Vorotan, Meghriget, and Voghji Rivers and their watersheds, are in progress. The draft final report on the Vorotan is ready, and includes comments from the stakeholder institutions and ministries. It will be discussed with the public in April 2014.
In progress	European Union	The Akhuryan-Metsamor RBMP is being prepared within the European Union Environmental Protection of International River Basins Project.

Note: GEF = Global Environment Facility; UNECE = United Nations Economic Commission for Europe; UNDP = United Nations Development Programme.

be included in each RBMP was adopted by the government. The Content of Model Water Basin Management Plan Protocol, which draws heavily on the European Union Water Framework Directive, currently provides the basis for the development of RBMPs in the country. The protocol, however, is not fully consistent with the Water Code, which specifically stipulates that the basin plans "shall balance the interconnected relationship of all water users, including communities, power generation, industry, agriculture, and environment." The European Union Water Framework Directive takes a narrower approach and focuses mainly on the protection of the aquatic ecosystem (USAID 2012b). Under the ongoing Clean Energy and Water Program, USAID has been

Map 4.2 Coverage of RBMPs in Armenia



Note: A full-color version of this map may be viewed at http://www.issuu.com/world.bank.publications/docs/9781464803352.

supporting the government of Armenia in the development of a further improved framework. Table 4.7 provides a comparative analysis of the content of the current and proposed model RBMP.

While the USAID-proposed revised model RBMP is a step in the right direction toward improving the structure of the RBMP, there remain additional adjustments to consider in the overall planning framework. This includes ensuring that the framework addresses issues of competition between different users to ensure efficient water use, the balancing of available water supply and demand during the dry season, effective flood management during the wet season, climate change resilience and adaptation, river basin transfers, and protection and conservation. Most importantly, the RBMPs must be clear on how various planning and investment choices in the water sector (across all subsectors) link with other economic sectors in the Armenian economy, such as energy, agriculture, and mining. These planning efforts are also opportunities for the government of

Table 4.7 Comparative Analysis of Content of Current and Proposed Model RBMP

Component	*Content of current model RBMP*	*Content of proposed model RBMP*
Issue Identification	Main description of the river basin	River basin characterization
	Identification of current conditions and functions in the river basin	Identification of current status of water use and activities in the river basin
	Assessment of natural and anthropogenic impacts on water, including assessment of climate change impacts	Assessment of natural and anthropogenic pressures and impacts on water resources of the river basin
Priority Setting	Identification of desired conditions and functions in the river basin	Identification of desirable status of water use and activities in the river basin
	Classification of water bodies of the river basin delineated according to management peculiarities	Classification of water bodies delineated according to peculiarities of water resources management
	Definition of the ecological flow of water bodies in the river basin	Calculation of environmental flow for water bodies in the river basin
	Identification of measures toward achieving the desired conditions in the river basin	Program of measures for achieving desirable status
	Identification of measures to mitigate the possible consequences of and prevent emergency situations in the river basin	Defining measures for prevention, mitigation, and elimination of consequences of emergency situations
	Assessment of water use demand in the river basin according to sectors	Assessment of water use demand by sectors in the river basin
	Water resources improvement scenarios according to sectors	Water resources improvement scenarios by sectors in the river basin
Economic and Financial Considerations	Preliminary financial assessment of identified measures	Preliminary economic and financial assessment of measures identified
	Assessment of existing financial deficit in the river basin according to sectors	Assessment of financial deficit by sectors in the river basin
Stakeholder Involvement	Involvement of public and stakeholder institutions in decision making	Involvement of public and interested agencies in decision-making process
Implementation and Monitoring		Provisions for continuous implementation of the RBMP

Source: USAID 2012b.

Armenia to examine water resource allocation scenarios across the full range of departments involved.

Moving forward, the government will need to invest budgetary resources in these multi-departmental basin planning efforts. To date, all basin planning efforts have been supported by external donors. This potentially poses two problems. First, the scope of the basin plans will be dictated, to some degree, by the donors and their interests. Second, the basin plans have relied heavily on the use of external consultants (often internationals) with limited long-term involvement with the BMOs. The BMOs are the owners of these RBMPs and ought to be driving the diagnostics of the basin and the participatory planning process. A case in point is the approach adopted for the formulation of the Akhuryan-Metsamor RBMP.[3] According to the recent call for proposals under the Environmental Protection of International River Basins Project, the basin plan will be consistent with the requirements of the European Union Water Framework Directive, as the program is funded by the European Union. As the objective of the project is to improve water quality, it is very likely that the primary focus of the basin plan will be on achieving a desired water quality status and not on broader water resources planning issues.

Conclusions

Despite these various basin planning efforts, so far no basin plan has been completed and approved by the government. Government endorsement of such plans is needed to ensure that all levels of government have a common planning vision and a clear prioritization of future investments in the sector. As a result, analysis of and knowledge on what would be the best allocation (in economic and efficiency terms) for the different water users in each basin are not available. This is despite the fact that water permit and allocation decisions are routinely being made. Currently, the planning of irrigation, water supply, and hydropower investment programs, which are managed at the central level, has limited relationship with the RBMPs. Thus, a clear disconnect exists between the basin plans and the sector programs and budgets. In moving forward, the government will need to invest in multidepartmental basin planning efforts. The RBMPs must be clear on how various planning and investment choices (across all subsectors) contribute to the overall economy of the country.

Strengthening the Water Permit System

Key Messages

- The permitting process is the main regulatory tool for IWRM.
- The Water Resources Management Agency (WRMA) is the agency responsible for issuing permits. This function is expected to be devolved to the basin management organizations (BMOs) as their capacities develop.
- Ensuring compliance of water permits is currently insufficient due primarily to lack of resources and agency capacity.

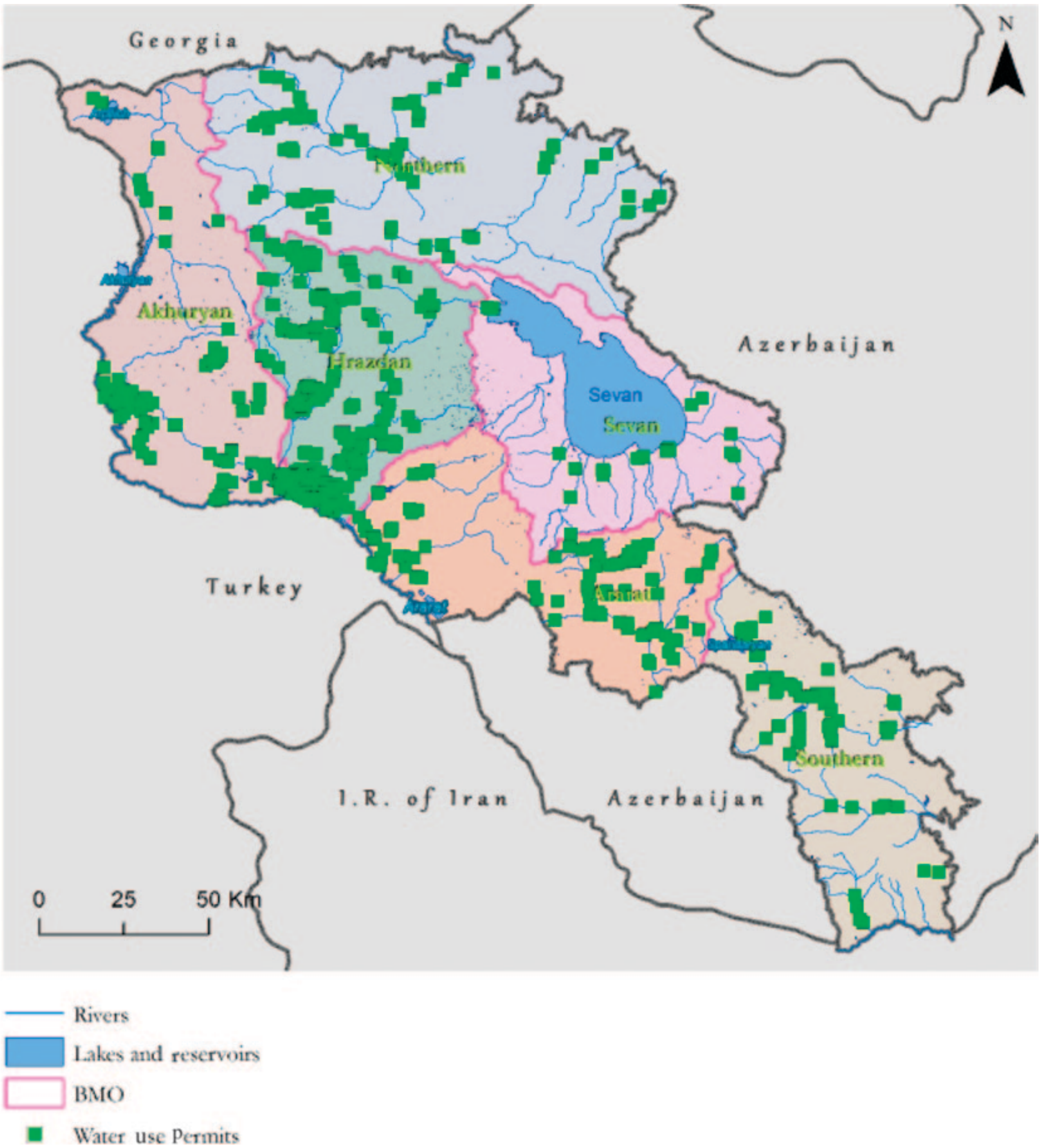
- Compliance involves a monitoring function and an enforcement action function. These roles and responsibilities have been separated under the current legislative framework.
- Greater cooperation (perhaps legislated) on inspection and enforcement is needed between the WRMA and the SEI to reduce duplication and overlap in functions and increase monitoring efficiency.
- Compliance history can be made a more explicit part of the permitting process.
- Compliance promotion (and more reliance on self-monitoring) is weak.
- Categorizing the size of water uses and pollution discharges, including establishing a limit for which a water use permit (WUP) is not required, would help to enhance agency efficiency.
- Greater public participation in the permitting process may be envisioned.

Background

Following the 2002 Water Code (chapter 4, articles 21–37), the Law on Environmental Oversight (2005), and the Law on Preparing and Implementing Inspections in Armenia (2000), the legal provisions for water use permitting have been established. Though the legislation provides the broad contours of how WUPs are to be applied, including the application process, contents, and criteria for review, it does not provide adequate guidance on compliance assurance and enforcement. Moreover, the full effectiveness of the water permit function is not possible due to lack of human, technical, and financial resources for compliance and weak public participation input (USAID 2007). In May 2011 the government of Armenia adopted Decision 677-N on making changes to Decision 218-N, dated March 7, 2003, on establishing standard forms of WUP and approving WUP forms. These changes improved the existing procedures on issuance of WUPs by stipulating additional procedures for issuance and extension of duration of the permit, and for providing hydrogeological data obtained from the Hydrogeological Monitoring Center of the Ministry of Nature Protection. These changes also allow for electronic submission of applications for permits and issuance of permits. Map 4.3 shows the locations of WUPs as of 2008.

The WRMA has the primary responsibility of issuing WUPs.[4] More specific guidelines on the permitting process were prepared in 2003 to support the WRMA. The guidelines—which have not been legislated—provide detailed descriptions of the permitting process, the rights of the applicant, evaluation criteria, public notification and input measures, and other useful guidance (both for applicants and for the WRMA). The steps given in the guidelines are shown in figure 4.1. The water use application contains a basic description of the proposal for water use and an analysis of its possible effects on water resources, ecosystems, protected areas, and people. The WUP applies to withdrawals from surface water and groundwater and controls the amount of extraction and the discharge quality. The WRMA determine the necessity of performing an environmental impact assessment. Public input is solicited at various points in the permitting process. No other water management agencies (for example, the State

Map 4.3 Locations of Water Use Permits



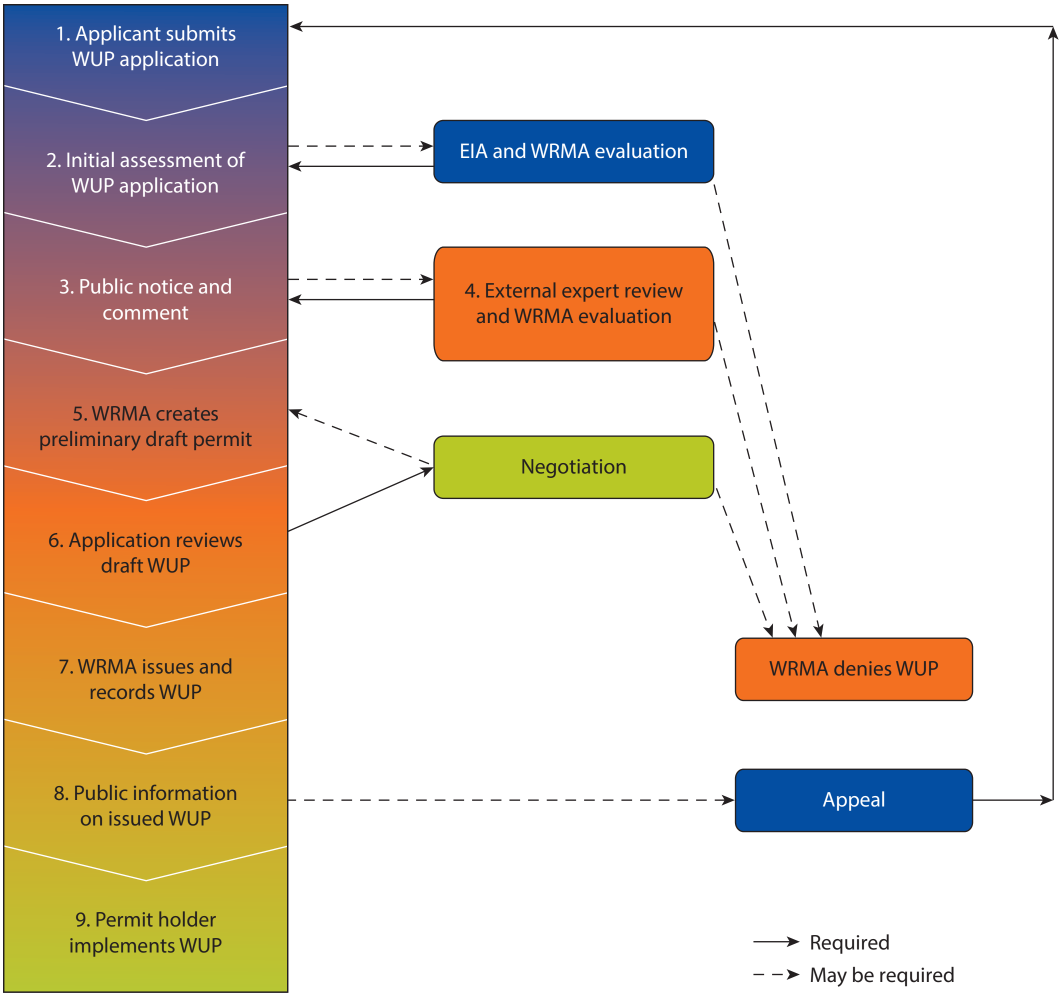
Source: USAID 2008.
Note: A full-color version of this map may be viewed at http://www.issuu.com/world.bank.publications/docs/9781464803352.

Committee on Water Economy) have a formal role in the permitting process. BMOs in the future are expected to take over this role.

Typical contents of a water permit application are the following:

- Address of the water user;
- Water use site;

Figure 4.1 Application and Issuance Processes for Water Use Permit



Source: USAID 2005.
Note: WUP = Water Use Permit; WRMA = Water Resources Management Agency; EIA = Environmental Impact Assessment

- Water abstraction site;
- Purpose of water use;
- Volume of water use, including from surface water resources and groundwater resources;
- Water use period and regime;
- Control mechanism to ensure the conditions of the WUPs;
- Allowable volumes of wastewater discharged into water resources or their watersheds;
- Description of discharge;
- Data on marginal allowed discharges of hazardous substances;
- Water standards and related information;

- Special measures that will be applied to promote efficient water use and improve water quality, wetlands and other important habitats, and related biodiversity;
- Corresponding requirements for water use calculation, monitoring, registration, and correction;
- Corresponding guarantees in case of causing damage to water resources;
- Payments associated to water use and payment schedule;
- Number of days within which the water use is subject to registration at the State Water Cadastre.

The Water Code (article 35) provides that a WUP holder may sell or otherwise transfer, in whole or in part, their WUP to a third party. The Water Code also provides for the inheritability of WUPs. There is debate as to whether this is appropriate (USAID 2007).

Despite significant progress made in WUP procedures during the last several years, there are still gaps and insufficiencies in the existing procedures. These include primarily (a) lack of regulations defining the marginal quantities of water use that do not require a WUP (as required by article 22 of the Water Code); (b) weaknesses in compliance and enforcement; and (c) low rate and fragmented nature of implementation, despite the formal public notification requirement.

Compliance and Enforcement

The Ministry of Nature Protection designates the SEI as the primary agency responsible for the enforcement and oversight of WUP requirements. The mandate of the SEI goes beyond enforcement of the permit requirements and includes enforcement of other environmental legislation related to air quality, biodiversity, soils, waste, and hazardous substances (for example, permits to emit into atmosphere, waste disposal permits, and permits to use and protect underground). Supported by the Law on Environmental Oversight, the SEI is authorized to:

- Enforce restrictions on the illegal and improper use of water resources;
- Enforce compliance with the requirements of water use, whether or not permitted;
- Establish and monitor parameters on the pollution of water resources in excess of the established limits;
- Enforce restrictions on water use in catchment basins;
- Enforce the rules related to maintaining the State registration of water resources;
- Ensure compliance with the requirements for the placement of landfills, dumps, cemeteries, and other facilities that may have an indirect harmful impact on water resources;
- Ensure compliance with the requirements for work within a specified distance of water resources that may affect or significantly impact the water resources;
- Ensure compliance with the requirements for recreational use of water resources;

- Ensure compliance with the national water program defined norms, limits, and restrictions for the use and preservation of water resources.

Moreover, the Law on Environmental Oversight provides guidance on the procedures for sanctions for noncompliance (including the fine and penalty structure), the use of inspections and examinations, and the rights and responsibilities of the water user permit holders. Currently, the SEI is not involved directly in the actual permitting process (for example, by providing compliance history information as part of the review process).

The SEI has 220 professional employees and 30 support staff. The challenges that the SEI faces in effectively performing its duties are well documented (USAID 2007). Due to insufficient funding, inadequate laboratory infrastructure and equipment, lack of sufficient technical tools and equipment (for example, computers and local and wide area networks), lack of appropriate trained personnel (such as environmental engineers), poor data transfer protocols, and difficulties with the recruitment procedures, the activities of the SEI related to water are largely impaired, and for most of the water users, there is no reliable information on whether they comply with the provisions mentioned in the WUPs or not. Thus, currently the level of compliance assurance and enforcement of the WUP conditions is insufficient.

It should be noted that this environmental oversight function is in contrast to the function that the WRMA and BMOs play. If the WRMA or BMO identifies a noncompliant permit holder, they write a detailed report and send it to the SEI. However, cooperation and information exchange among the BMOs, the SEI, and the Environmental Impact Monitoring Center is minimal. This is essential to the overall permit system, given that the SEI is required to measure the direct discharges, the Environmental Impact Monitoring Center is required to measure the quality of the receiving surface water body, and BMOs are in charge of State supervision of uses. Thus, to enhance this oversight, more coordinated action between agencies is needed. Legislative clarification of each agency's responsibility in relation to compliance assurance may be needed.

With regard to the Water Code, each WUP shall also clearly identify an adequate means of recording, monitoring, reporting, and verifying the water use and discharge by the permit holder. Thus, the water user is obligated to provide some level of self-monitoring. Currently, Parliament is reviewing the Law on Implementing Self-Monitoring of Requirements of the Environmental Legislation. Article 13 of the draft law outlines the self-monitoring and reporting procedures for discharging substances that pollute water resources and for using water in the production cycle. The self-monitoring is applicable to water users annually discharging over 1 tonne of biological oxygen demand or suspended particles or 100 kilograms of heavy metals, as well as to water users that abstract over 10 liters of water per second (except for hydropower and fishery sectors). Thus, strengthening this system of self-monitoring will help reduce the burden of compliance assurance on the public agencies and the response time to any environmental problems that may arise.

Public Participation in Issuing Water Use Permits

To provide greater transparency and public participation in the decision-making process, public notice and environmental impact assessment requirements are part of the WUP application process. These are highlighted in the Water Code. Article 5 (on basic principles of management, use, and protection of water resources and water systems) recognizes the importance of public participation and awareness in the process of management and protection of water resources. Article 20 (on public participation) lists the items that are subject to public notice (for example, draft RBMPs, pending WUPs, draft water tariff strategy, and draft water standards). Article 106 (on participation of nongovernmental organizations and citizens in the protection of water resources and water systems) defines the role of nongovernmental organizations and citizens in this process. The Water Code also provides a mechanism by which the public may file a complaint on a WUP decision. Finally, the specifics on public consultation are fixed in government Resolution 217-N of March 7, 2003, on Approving the Procedures for Ensuring Public Notification and Transparency of Documents Developed by the Water Resources Management and Protection Body, and its subsequent amendment of March 3, 2005.

The current permit guidelines require public notification and comment at the initial review process and then after a final decision. They do not require public notification on the proposed decision. Hence, potentially affected stakeholders do not have an opportunity to study any reports on the impact of the proposed application and the proposed permit conditions before the final decision. Thus, the procedures for public notification and appeal need improvement. The WRMA should provide ample time to the public to study the results of any impact studies, the justification of the proposed decision, and the proposed conditions for the permit. A few weeks after the provision of this kind of information, a public hearing could be organized by the BMO.

Conclusions

WUPs are one of the key tools for management and allocation of water resources in the country. Improved implementation of the WUP system is still constrained by (a) deficiencies in permitting regulations (for example, free water use, which is described in article 22 of the Water Code, is not defined yet, and the potentially affected stakeholders and public do not have an opportunity to study any reports on the impacts of the proposed application); (b) insufficient cooperation among agencies of the Ministry of Nature Protection in the processes of issuance of permits and the assurance of compliance with permit conditions (particularly between the WRMA/BMOs and the SEI); and (c) capabilities and resources of agencies and their staff (for example, the list of pollutants is too long, and most of the pollutants in the list cannot be effectively monitored by the SEI). To improve the permit system, categories may be defined for small, medium, and large water use and pollution discharges. Categorization is needed as large withdrawals require a more comprehensive and complex impact study and public notification process than small withdrawals. Also, establishing a limit below which a WUP is not required would help to reduce the agency burden. This would give the WRMA/BMO more time to process and focus on those permit applications that have a significant impact (and strategic impact) on the local water system and its users.

The Future of Ararat Valley

Key Messages

- The agriculture and fishery sectors are of strategic importance to the Armenian economy; Ararat valley is the largest agriculture and fish farming zone.
- Since 2006, a large number of fish farms have been established in the Ararat valley, in part due to the rich supply of artesian groundwater of high quality and low cost.
- Due to both overissuance of water user permits and overabstraction of groundwater resources above permitted levels or without water user permits, artesian groundwater resources are sharply depleting.
- Due to artesian groundwater depletion, the conflicts with other artesian groundwater uses—irrigation, domestic, industrial, and cooling waters—are increasing.
- Increasing water discharge from fish farms is overloading the drainage network, causing higher operation and maintenance costs, waterlogging, soil salinization, and alkalization.
- Several measures are being put in place. However, coordinated action across several ministries is required.

Background

The Ararat valley is the largest plain in Armenia (photo 4.2). It is divided into two parts—the northern part in Armenia and the southern part in Turkey. In Armenia,

Photo 4.2 Ararat Valley

Source: ©World Bank/Ju Young Lee. Used with Permission; further permission required for reuse.

the Ararat valley covers two administrative territories (parts of Ararat and Armavir marzes) and three BMOs (Akhuryan, Hrazdan, and Ararat). The valley is located at 800–1,000 meters above sea level and occupies an area of about 1,300 square kilometers on the Armenian side (map 4.4) (USAID 2014). The soil is fertile and the climate conducive to crop production. The Ararat valley is the largest agricultural zone in Armenia, providing up to 40 percent of the agricultural GDP (USAID 2012a). Various crops for export and local consumption are produced, including wheat, vegetables, grapes, and other fruits.

Map 4.4 Location of Ararat Valley

Source: USAID 2014.
Note: A full-color version of this map may be viewed at http://www.issuu.com/world.bank.publications/docs/9781464803352.

The Ararat valley is rich with high-quality artesian groundwater, which is suitable for drinking purposes without additional treatment and comprises a strategic reserve of drinking water for the country. The artesian groundwater is at a depth of about 100–180 meters and is under high pressure.[5] This resource has historically been used for drinking and irrigation purposes. In recent years, fisheries have become one of the major water users (USAID 2012a).

During the last decade, development of private fish farms in the Ararat valley has significantly intensified due to the availability of low-cost, high-quality artesian groundwater, which supports year-round industrial production of fish. The number of fish farms in the valley has increased from just a few in the 1980s to 190 in operation in 2013 (109 in Ararat marz and 81 in Armavir marz) (USAID 2014). In 2013, the aquaculture fish production was 11,520 tonnes in Armenia. According to the Ministry of Agriculture, the potential for fish production is as much as 25,000 tonnes per year (FAO 2011). Given the continued domestic and international demand for fish,[6] the fish industry is of strategic importance to the country. However, along with the uncontrolled expansion of fish farms, there are growing concerns over the unsustainable use of groundwater. Box 4.3 presents further information on the economics of fish farming in Armenia, while figure B4.3.1 illustrates the growth in fish farming; box 4.4 gives data on a sample fish farm, and photo B4.4.1 shows pictures of the farm.

Groundwater Uses and Depletion in Ararat Valley

Groundwater abstraction currently exceeds the sustainable yield. The renewable level of groundwater use in the Ararat valley has been assessed by various authors. In 1984, the State Committee on Reserves approved a safe annual yield of artesian groundwater resources of 1,785 million cubic meters (MCM) per year (1,094 MCM from wells and 691 MCM from natural springs) (USAID 2014). According to various experts, these levels are still reasonable and do not need to be reassessed (USAID 2014). Even before the intensive development of the fish farming industry (around 2007), groundwater use in the Ararat valley already exceeded this renewable level (figure 4.2). According to the Hydro Institute inventory of wells and springs in the Ararat valley in 2007, there were 1,986 wells abstracting 1,151 MCM per year (USAID 2013). For fish farming, 299 wells were abstracting 401 MCM per year.

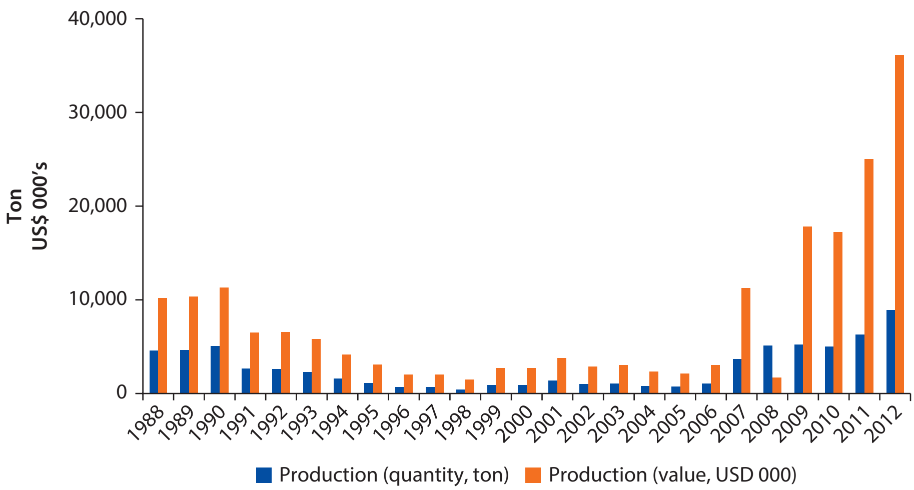
Fish production was included in the list of priority development programs in 2008 and thus more WUPs were issued (USAID 2014). In the period 2008–13, WUPs were issued for 274 new wells with a total discharge of 735 MCM per year, of which 202 were for fish farming (table 4.8). As a result, the actual groundwater abstraction from fish farms has increased by 719 MCM per year. It should be noted that this increase is concentrated mainly in the Ararat valley (Masis in Ararat marz and Echmiadzin in Armavir marz).

Considering both groundwater uses with and without WUPs, the total groundwater use in 2013 was 1.6 times the level approved by the State Committee on Reserves. Groundwater use by fish farms alone exceeded this level (figure 4.5). Though the actual abstraction from permitted wells for all

Box 4.3 Economic Value of Fish Farming in Armenia

In 2013, there were 335 fish farms officially registered in Armenia, of which 250 are operating. The total water area of fisheries in Armenia is 3,542 hectares. Fish farms, in terms of number and water area, are mostly concentrated in the Ararat Valley. As shown in figure B4.3.1, aquaculture fish production has been growing since 2007. It was 8,850 tonnes in 2012, 11,520 tonnes in 2013, and is estimated to reach 13,800 tonnes in 2014. Fish exports are also increasing: 1,800 tonnes in 2012 and 2,400 tonnes in 2013. In terms of value, by 2012 fish production was valued at around US$36 million (15 billion Armenian drams [AMD]). This means on average over US$4,000 (1.7 million AMD) per tonne of fish and over US$10,000 (4.2 million AMD) per hectare of fish farm.

Figure B4.3.1 Aquaculture Fish Production in Armenia



Source: FAO FishStat database: http://www.fao.org/fishery/statistics/en.

Source: FAO FishStat database: http://www.fao.org/fishery/statistics/en. FAO 2011. Ministry of Agriculture.

Box 4.4 Sample Fish Farm in the Ararat Valley

Basic facts

- Location: Dashtavan, Ararat marz
- Operation: since 2007
- Area: 3 ha (slightly larger than the average small fish farm size)
- Fish species: sturgeon and trout, which is indigenous from Lake Sevan
- Production: 50–60 tonnes/yr

box continues next page

Box 4.4 Sample Fish Farm in the Ararat Valley *(continued)*

Photo B4.4.1 Pictures of Sample Fish Farm

Source: ©World Bank/Ju Young Lee. Used with Permission; further permission required for reuse.

- Energy consumption: none (artesian wells and gravity-fed pipes)
- Initial investment: 400 million AMD or US$1 million (including well drilling cost of 6–7 million AMD or US$15,000–17,500 per well)

Water resources assessment (*MCM = million cubic meters)

- Water source: one artesian well
- Permitted amounts: 50 L/s (= 1.6 MCM/yr)
- Actual intake: 200 L/s in 2007 to 150 L/s now (150 L/s = 4.7 MCM/yr) (50 L/s per ha)
- Expected to dry up in three years (the neighboring village is already experiencing negative pressure for their artesian wells and 5 m drop in the shallow groundwater table)
- Drainage: discharged directly to the irrigation drainage right next to the farm

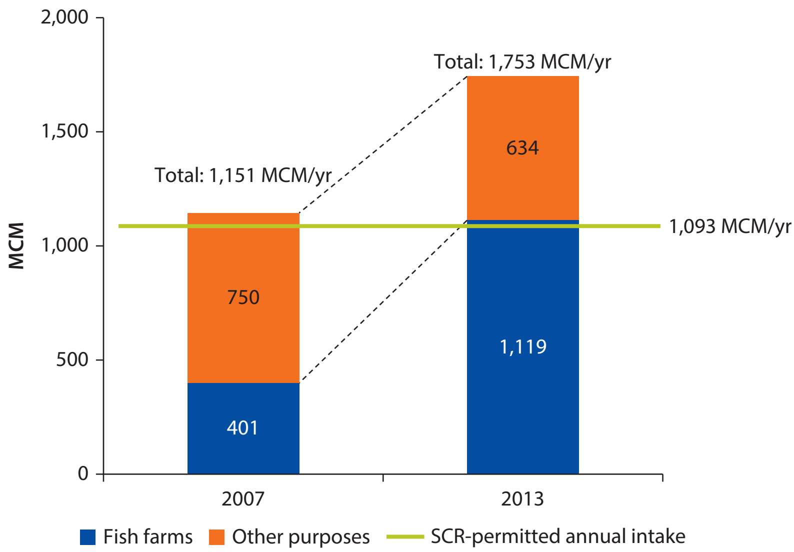
box continues next page

Box 4.4 Sample Fish Farm in the Ararat Valley *(continued)*

Farm budget

- Expenses: 1,000 AMD/kg fish (US$2.5/kg)
- Selling price: 1,800 AMD/kg fish (US$4.5/kg)
- Net profit: 800 AMD/kg fish (US$2/kg)
- Annual Net profit: 50 million AMD or US$120,000/yr (800 AMD/kg or US$2/kg x 60,000 kg)
- Net profit per volume: 12 AMD/m^3 or US$0.03/$m^3$ water (50 billion AMD/yr or US$120,000/yr * 1yr/4.7 MCM)
- Productivity: 0.013 kg fish/m^3 water (= 60,000 kg fish/4.7 MCM)

Figure 4.2 Discharge of Operating Wells in Ararat Valley in 2007 and 2013



Source: USAID 2014.
Note: "Other purposes" include irrigation, drinking, and industrial water uses; MCM = million cubic meters.

Table 4.8 New Water Use Permits Issued 2008–13

Total number of new permits and abstraction allowed	*Of which for:*			
	Fishery	*Irrigation*	*Potable*	*Industrial*
274 permits for 735 MCM/yr	202 permits for 700 MCM/yr	56 permits for 32 MCM/yr	12 permits for 2.3 MCM/yr	4 permits for 0.2 MCM/yr

Source: USAID 2014.
Note: MCM = million cubic meters.

water uses (1,337 MCM per year) was less than the amounts of those permits (1,571 MCM per year), total abstraction was greater for two reasons. First, in some cases, fish farms are abstracting more water than allowed in their WUPs. Second, there are illegal wells operating without WUPs. There are 531 wells abstracting 416 MCM per year without WUPs, including 35 fish farming wells discharging 47 MCM per year without WUPs. Table 4.9 summarizes the water uses by fish farms with and without WUPs. Looking at the distribution of fish farms, out of the total 190 in operation, there are 22 fish farms using more than 9.5 MCM per year (or 300 liters per second), and their water uses amount to 57 percent of the total water use of fish farms. Table 4.10 presents the water uses by fish farms taking more than 9.5 MCM per year. Appendix F povides the list of those 22 fish farms and more details on their water uses.

As a result of continued overpermitting and overabstraction of groundwater, the artesian groundwater zone has decreased (map 4.5). Between 1983 and 2013, piezometric levels decreased on average by 6–9 meters, sometimes by as much as 15 meters. Well discharges have reduced by 6–200 liters per second. The artesian zone in the valley has also significantly reduced. The artesian zone decreased from 32,760 hectares in 1983 to 10,706 hectares in 2013. The cone of depression has also extended, now reaching the Sevjur-Aknalich springs, located near Echmiadzin. Flows have decreased to one third of the 2007 levels (from 309

Table 4.9 Fish Farm Wells and Intake in Ararat Valley

No. of fish farms		*Number of fish farm wells*				*Fish farm intake (MCM/yr)*		
Total	*Actually operating*	*Total, with permit*	*Actually operating, with permit*	*Actually operating, without permit*	*Wells operating by pumps*	*Permitted volume*	*Actual intake, with permit*	*Actual intake, without permit*
267	190	576	470	35	44	1,361	1,072	47 (4.2% of total actual intake, 1,119)

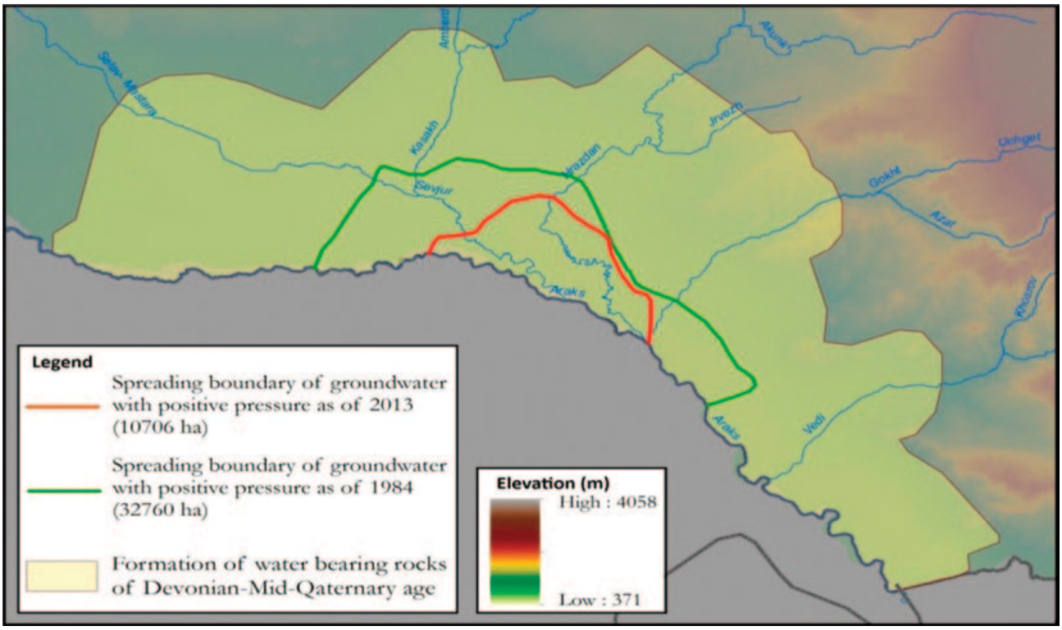
Source: USAID 2013, interim report part 2.
Note: MCM = million cubic meters.

Table 4.10 Water Use by Fish Farms (Water Intake > 300 L/s or 9.5 MCM/yr)

Water intake	*Number of operating fish farms*	*Total water intake by these fish farms*	*% in total water intake of all fish farms in Ararat valleya*	*% of water reduction achievable by 70% semi-recycling technology applied to fish farms*
> 1,000 L/s (32 MCM/yr)	3	309 MCM/yr	28	19
> 500 L/s (16 MCM/yr)	13	531 MCM/yr	47	33
> 300 L/s (9.5 MCM/yr)	22	639 MCM/yr	57	40

Source: USAID 2013, interim report part 2.
Note: L/s = liters per second; MCM = million cubic meters.
a. Total water intake by all fish farms in Ararat valley is 1,119 MCM/yr.

Map 4.5 Observations on Changes of Groundwater Levels and Artesian Zone in Ararat Valley



Source: USAID 2014.
Note: A full-color version of this map may be viewed at http://www.issuu.com/world.bank.publications/docs/9781464803352.

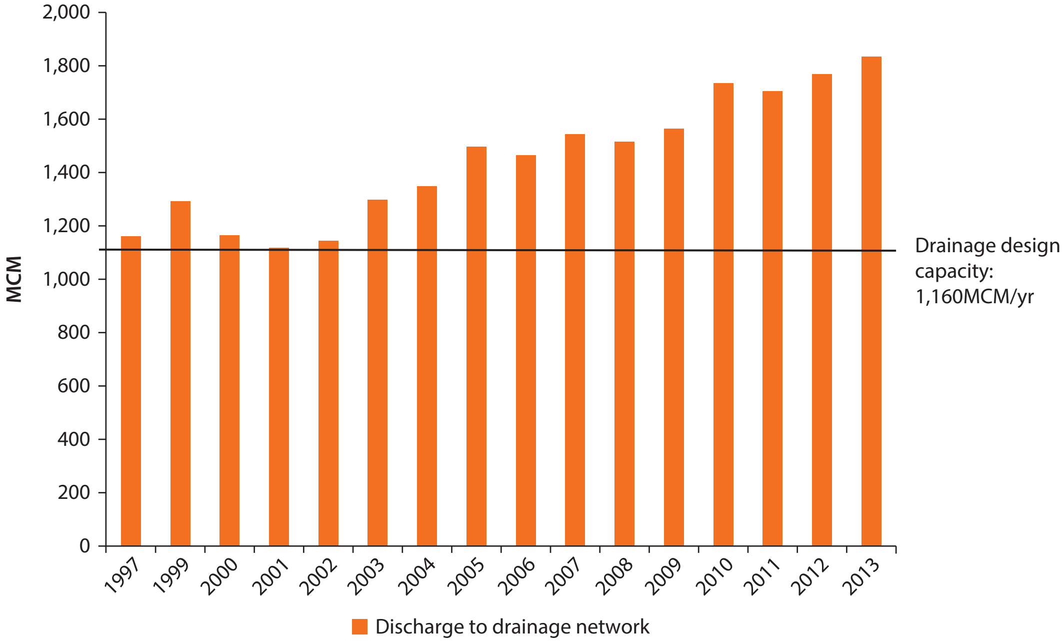
MCM in 2007 to 95 MCM in 2013). The flow of the Metsamor River, which is fed exclusively from groundwater, has also greatly reduced.

Conflicts with other artesian groundwater users—irrigation, domestic, industrial, and cooling waters—are growing. As the artesian area has reduced in the Ararat valley, the number of communities using artesian wells for irrigation and domestic water supplies has decreased from 44 in 1983 to 13 in 2013. For example, in Echmiadzin, 122 out of 303 previously artesian wells for irrigation and domestic water uses do not flow any more. Due to the reduced discharges of the Sevjur-Aknalich springs, the Armenian (Metsamor) nuclear power plant can take only 16 MCM per year, while its water requirement is 32 MCM per year.

Overloaded Drainage System

Discharge from fish farms is increasing the burden on the agriculture drainage system. There are 1,535 kilometers of operational drainage networks in Ararat valley, including 905 kilometers of open drains and 630 kilometers of closed drains. The drainage system was originally designed for agricultural drainage of up to 1,160 MCM per year. This system is increasingly overloaded with the growth of fish farms (as well as, to a lesser extent, industrial enterprises and communities). In 2012, 1,770 MCM per year was removed by the drainage system (figure 4.3), with about half—877 MCM per year—discharging from fish

Figure 4.3 Annual Discharge of Drainage Network in the Ararat Valley, 1997–2013



Source: USAID 2013, interim report part 2.
Note: MCM = million cubic meters.

farms in violation of the *water discharge conditions set in their water permits.* This additional discharge results in increases in operation and maintenance requirements (extra financial burden for the State Committee on Water Economy) for the drainage network. Also, the increased water levels in collectors near the drainage network have caused waterlogging, soil salinization, and alkalinization. This ultimately reduces nearby agricultural crop yields. Currently, the State Committee on Water Economy is revising its fees to make fish farms pay 0.33 AMD per cubic meter of water discharged to the drainage system in the Ararat valley.

Efforts to Address the Issue

Recognizing the growing concerns about water resources in the Ararat valley, the government of Armenia established an interagency commission on the issue in late 2010. The commission conducted some research and advised the WRMA to issue no more permits for fish farms, though this was largely not followed. The commission was abolished a year after its establishment due to its ambiguous and weak function. Clearly, there is a need for an effective coordinating mechanism across several departments to monitor status of water resources management issues in the Ararat Valley. In the following years, several measures were adopted by the government, including stricter regulation over water use permitting and enforcement of permit conditions. Restrictions on drilling wells in certain zones of the Ararat valley were also used. As of January 1, 2014, the water abstraction fee was also increased for fish farms. While the water abstraction fee per volume remains the same at 1 Armenian dram per cubic meter, the fee is applied to 50 percent of the overall abstracted volume instead of 5 percent, as was previously done.[7] The Ministry of Territorial Administration is also monitoring water usage by fish farms.

In June 2013, the Ministry of Agriculture instructed fish farms to use semi-closed water recycling (for large, medium, and small fish farms in one, three, and five years, respectively). Many fish farms are opposing such a mandate because of the high cost and perceptions that the quality of the fish will be worse with such technologies. As shown in table 4.10, targeting large fish farms would bring substantial water savings. Several private sector entities and international organizations—for example the Food and Agriculture Organization of the United Nations (FAO)—are providing technical assistance on the use of such recycling technologies. Recently, USAID (2014) assessed the groundwater resources in the valley. The study provides supporting data to assess the current situation and proposes to strengthen monitoring and take appropriate measures (temporary closure, liquidation, and conversion to valve operation) to bring water use to a sustainable level.

Conclusions

Since 2006, there has been uncontrolled development of private fish farms in the Ararat valley, in part due to the rich supply of artesian groundwater of high quality and low cost. The returns to this industry are quite good (boxes 4.3 and 4.4). However, current use by these farms significantly exceeds sustainable yields. Changes in the artesian zone and well pressures are already being observed. Moreover, excessive discharge into the agriculture drainage system is problematic. This is also resulting in conflicts with other artesian groundwater users in the valley—irrigation, domestic, industrial, and cooling water uses. Finally, the situation in the Ararat valley is indicative of the larger problems discussed in the previous chapters with respect to weak monitoring and absence of RBMPs. It is clear that WUPs were issued without a sufficient understanding of the water resources base and the existing water uses in the area. While short-term measures to restore and conserve artesian groundwater are being taken, coordinated action across a variety of departments responsible is urgently needed.

Transboundary Water Resources Issues

Key Messages

- The primary focus of most existing bilateral agreements and treaties between Armenia and its riparian countries, particularly those concluded with the Islamic Republic of Iran and Turkey, relates to water allocation.
- Existing agreements on transboundary waters are silent with regard to groundwater issues.
- Implementation of bilateral agreements between Armenia and Turkey remains low.

- Major water infrastructure plans by Turkey to be used for irrigation, water supply, and hydropower are a major government concern because of the potential impacts.
- To date, not much has been done with respect to bilateral Armenia-Turkey cooperation. The government has expressed willingness to collaborate with Turkey in the construction of a joint multipurpose dam on the Araks River along the Armenia-Turkey border (Surmalu dam) for which a joint technical concept has been prepared.
- The formal role of the WRMA with regard to transboundary water issues is not properly addressed in the current legal framework.
- Lack of formal cooperation between all the riparian countries and lack of legal framework for transboundary cooperation are major limitations for making progress on this front.

Introduction

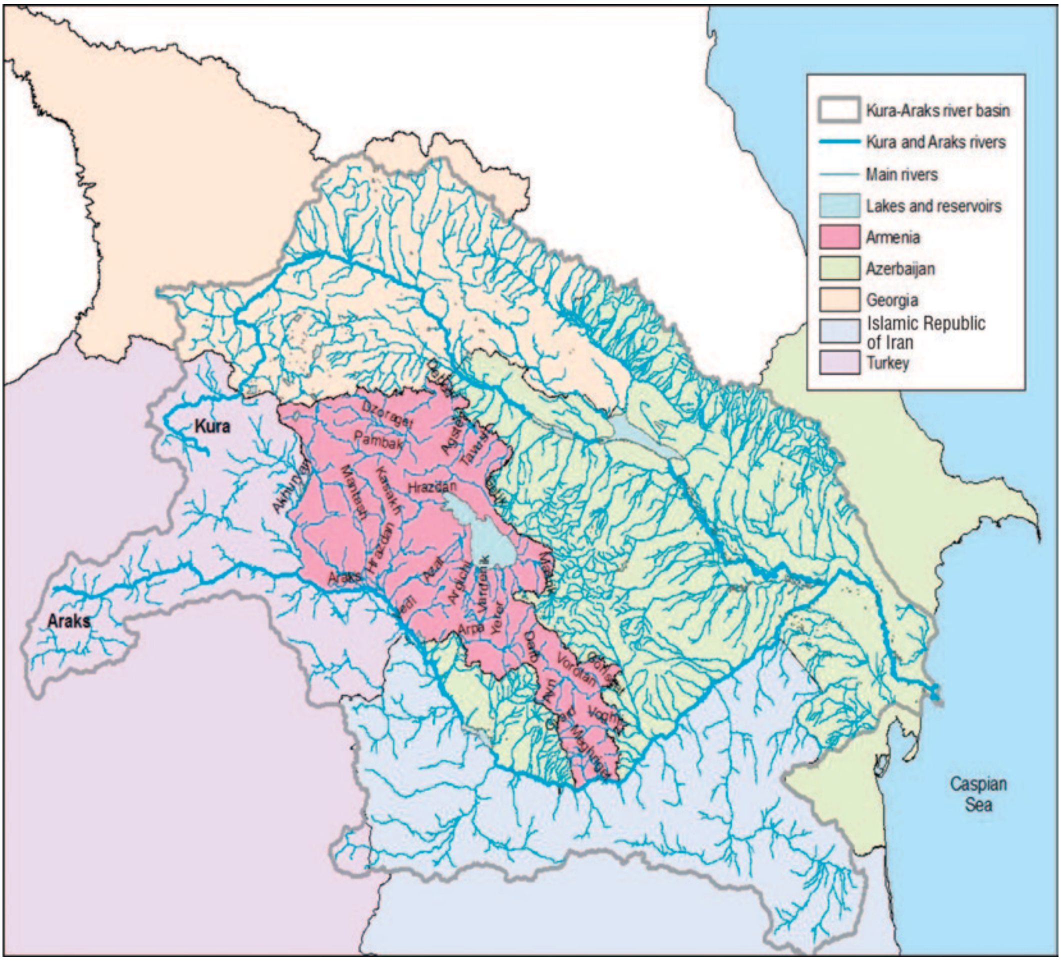
As indicated in earlier chapters, all of the territory of Armenia is located in transboundary river basins. Important transboundary rivers include the Kura and Araks (map 4.6).[8] The Kura basin is shared with Azerbaijan, Georgia, and Turkey, and the Araks basin is shared with Azerbaijan, the Islamic Republic of Iran, and Turkey. Armenian rivers are tributaries of the Kura and Araks: the Debed, a tributary of the Kura, is shared with Georgia; the Aghstev, also a tributary of the Kura, is shared with Azerbaijan; the Akhuryan, a tributary of the Araks, is shared with Turkey; and the Vorotan, the Arpa, and the Tavush, also tributaries of the Araks, are shared with Azerbaijan. Average annual transboundary surface water inflows and outflows are presented in appendix G. Shared groundwater resources add another level of complexity. Characteristics of principal transboundary aquifers are summarized in table 4.11. According to available information, the Debed aquifer is under the greatest stress (Wada and Heinrich 2013).

Reduction in water availability due to the ongoing developments by Turkey is a major concern for the Armenian government. Existing and planned hydraulic infrastructure in the Araks basin by Turkey for consumptive (irrigation and water supply) and nonconsumptive (hydropower) uses will result in changes in the river flow regime as well as river dynamics and morphology (UNECE 2011).

According to long-term river discharge records of hydrological stations along the Akhuryan and Araks Rivers, which are shown in figure 4.4, a decreasing trend is observed in the flow from the Araks River at the Surmalu station, located downstream of the confluence with the Akhuryan River, even though the Yervandashat station, located upstream of the confluence, shows an increasing trend. As limited information is available on water extractions upstream of the Surmalu station over time, at present it is not possible to categorically conclude that the declining trend in the Araks River is due to upstream extractions for consumptive uses (Hannan, Leummens, and Matthews 2013).

Deterioration of water quality in transboundary rivers is also a concern, for example due to nonpoint source pollution from agriculture and livestock

Map 4.6 Map of Kura-Araks River Basin



Source: UNDP and GEF 2013.
Note: A full-color version of this map may be viewed at http://www.issuu.com/world.bank.publications/docs/9781464803352.

activities in the Araks and Akhuryan Rivers. Mining is also problematic as it relates to shared aquifers, such as the Aghstev-Tavush and Pambak-Debed aquifers. In these two transboundary aquifers, potential conflicts over the use of readily available resources are also expected as water demand in the riparian countries is increasing (Puri and Aureli 2009).

In addition to transboundary rivers and groundwater, there are important transboundary ecosystems shared by Armenia and Turkey in the Araks/Aras River valley. According to UNECE (2011), the Araks/Aras valley harbors several natural and artificial wetlands that provide important nesting areas for water birds. During the past decade, these wetlands have been under intensive pressure from the increasing development of fish farming. A particularly important site in Armenia is the Khor Virap marsh, which was designated a Ramsar site in 2007.[9]

Past and Ongoing Government Efforts

Development and use of international waters by Armenia is facilitated by a number of bilateral treaties and agreements. Most of them entered into force during the Soviet era. Nonetheless, Armenia has assumed obligations with respect to them. Bilateral agreements on transboundary waters entered into by Armenia and its neighbors are presented in appendix H.

Table 4.11 Characteristics of Principal Transboundary Aquifers

Transboundary aquifer	*Countries*	*Area (ha)*	*Stress index (low 0, high 1)*
Herher, Malishkin, and Jermuk aquifers	Shared between Azerbaijan and Armenia Weak links with surface water	13,066	—
Vorotan-Akora aquifer	Shared between Azerbaijan and Armenia Weak links with surface water	38,771	—
Aghstev/Akstafa-Tavush/Tovuz aquifer	Shared between Armenia and Azerbaijan Groundwater flow from Armenia to Azerbaijan Medium connection with surface water	713,329	0.11
Leninak-Shiraks aquifer	Shared between Armenia and Turkey Groundwater flow from Akhuryan-Arpacay subbasin to Ararat valley Medium links with surface water	516,021	0.04
Debed aquifer	Shared between Armenia and Georgia Alluvial aquifer upper part of the basin and volcanic-sedimentary rocks Medium links with surface water	36,299	0.51

Sources: UNECE 2011; Wada and Heinrich 2013.
Note: — = not available.

Figure 4.4 Time Series Annual Discharge Measured at Upstream and Downstream of the Confluence of the Akhuryan and Araks Rivers

a. Upstream of the confluence (Yerevandashat hydrological station on the Akhuryan River)

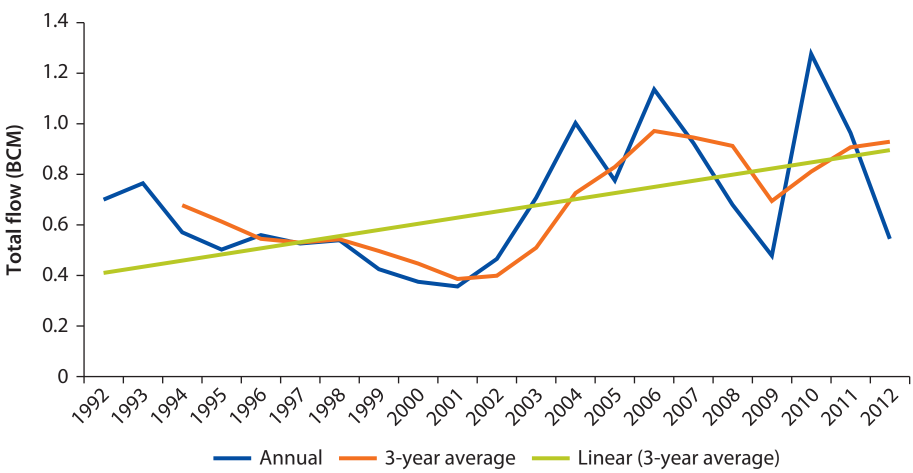


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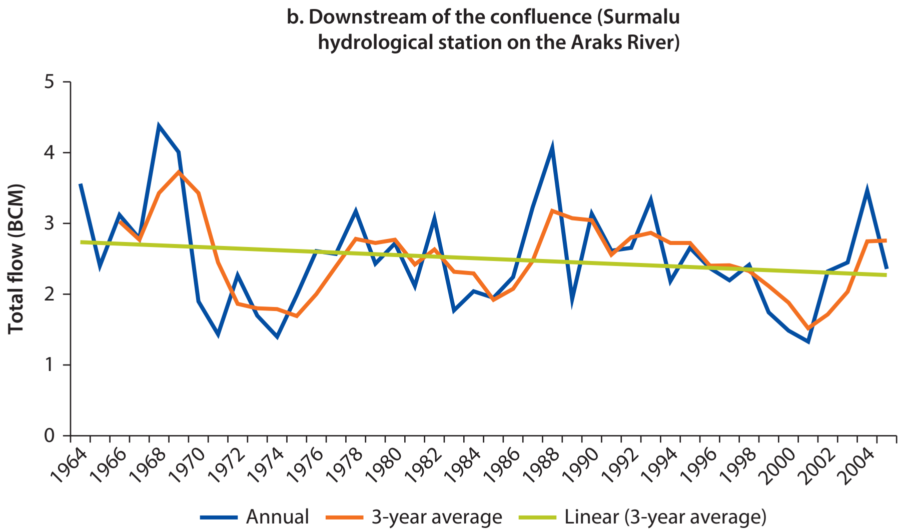
Figure 4.4 Time Series Annual Discharge Measured at Upstream and Downstream of the Confluence of the Akhuryan and Araks Rivers *(continued)*



Source: Prepared by authors with data provided by project implementation unit.

Armenia has an agreement with Turkey on the use of the Araks and Akhuryan Rivers. The Kars Protocol, concluded in 1927, includes provisions on the right to use a 50:50 allocation of the flow of the transboundary rivers, small rivers, and streams, as well as several basic regulations on infrastructure and dam construction. A protocol to the above-mentioned agreement was concluded in 1964 on the joint construction of the Akhuryan dam, which provided the basic rules for the joint construction of the dam and the sharing of its water on a 50:50 basis as well as the quantitative regulation of water use downstream of the dam up to the Iranian border. A permanent acting commission was established for the purpose of joint water use and technical exploitation of the Akhuryan reservoir. Another agreement was signed in 1973 on the construction of bridges and border issues on the Akhuryan River, which established basic rules on the regulation of the tributaries. In 1987 a technical and economic report was issued on a proposed reservoir on the Araks River to promote the comprehensive utilization of water resources (for irrigation and power generation) and prevention of channel erosion along the entire length of the Turkish-Armenian border. In 1990 an agreement was signed to address technical issues associated with the construction of joint hydropower facilities, which have not yet materialized, as well as changes in the riverbed and technical cooperation.

An agreement also exists between Armenia and the Islamic Republic of Iran on the joint utilization of the border areas of the Araks River for irrigation, power generation, and domestic use. According to the treaty, the two countries share the waters of the transboundary Araks River on a 50:50 basis. Cooperation schemes were also developed for the construction of joint hydrotechnical facilities, which did not materialize, and the collection of data.

There have also been decrees issued and agreements signed between Armenia and Georgia concerning the use of the Debed River. Similar decrees were passed between Armenia and Azerbaijan concerning the transfer of Arpa River waters into Lake Sevan; the regulation of the Vorotan River flow, which divides the Vorotan flow equally between the two countries and regulates the minimum flow during dry years; and the use of the Aghstev and Tavush Rivers.

Thus, the primary focus of most of the existing bilateral agreements and treaties between Armenia and its riparian countries, particularly those concluded with the Islamic Republic of Iran and Turkey, relates to water allocation. They may need to be revised to take into account water protection considerations. Furthermore, these agreements are silent with regard to groundwater. In general, no detailed provisions related to groundwater are provided. The existing agreements specifically apply to surface water.

Armenia has not signed the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) concluded under the aegis of UNECE. Concerns associated with the polluter pays principle embodied in the convention have deterred preparation in Armenia. Azerbaijan is the only Armenian neighbor that has ratified the convention. Armenia signed the 1999 Protocol on Water and Health, which is now in the process of ratification. The status of ratification of multilateral treaties and customary international law by Armenia and its neighbors is presented in appendix I.

Although the 2002 Water Code details the protocol to be followed to meet country obligations regarding transboundary waters, including the appointment of permanent inter-State committees for the solution of operational problems, it does not explicitly acknowledge the formal role of the WRMA. The Water Code requires that permanent inter-State committees present their decisions on the operation of transboundary water systems to the State Committee on Water Systems. While this arrangement is appropriate for the management and operation of joint hydrotechnical structures, it seems necessary to assign a specific role to the WRMA to facilitate the broader transboundary cooperation dialogue. The WRMA may play a key role in basic functions such as joint monitoring, data exchange, joint formulation of norms and procedures, identification of investments to optimize the use of joint resources, and negotiation of future agreements (PA Consulting Group 2005).

The Water Code also establishes the Armenian Commission on Transboundary Water Resources. The basic functions of the commission are formulation and submission to the government of draft inter-State agreements, notification to the relevant agencies of issues not regulated by inter-State agreements and requiring due resolution, and the provision of information to agencies in Armenia concerning the state of transboundary waters and transboundary impacts. The chair of the commission is the head of the WRMA, and the members include the deputy chair of the State Committee on Water Economy, the head of the ASHMS, and representatives of the Ministries of Agriculture, Health Care, National Security, and Foreign Affairs; the Water Design Institute; and the Irrigation Water Supply Agency. The commission largely exists on paper only and has no support staff. Thus, transboundary cooperation aspects are dealt with on a case-by-case basis (for example, Armenian-Iranian joint water quality monitoring is coordinated by the WRMA, and Armenian-Turkish joint hydrological measurements are coordinated by the State Committee on Water Economy).

Several donors have supported (and continue to support) transboundary cooperation efforts between Armenia, Azerbaijan, and Georgia. While all these initiatives are considered good attempts to promote cooperation and collaboration to protect transboundary resources, the lack of participation of the Islamic Republic of Iran and Turkey is a major limitation for making major progress on this front. Armenia is conscious of the need for regional engagement between all the riparian countries, in particular with Turkey, and would like to explore cooperation with its neighbor around technical discussions on potential joint investments in the Araks River.

Conclusions

Armenia shares transboundary water resources problems with its neighbors Azerbaijan, Georgia, the Islamic Republic of Iran, and Turkey. While the issues are complex, there is great potential for sharing the benefits of cooperation between the riparian countries in the Kura-Araks basin. The current level of cooperation is weak and ongoing support provided by the donor community to facilitate transboundary cooperation may require further enhancement. A critical area needing consideration includes inviting the Islamic Republic of Iran and Turkey to participate in this dialogue.

Building Water Storage Capacity

Key Messages

- Regulation of surface runoff is of strategic importance for the sustainable development of the irrigation sector in Armenia, particularly in the semiarid regions, where rapidly growing populations are facing depletion of groundwater resources.
- Per capita storage capacity in Armenia is much lower than the capacity of its neighbors, with the exception of the Islamic Republic of Iran.
- A strategic plan for the development of priority reservoirs in Armenia is needed that addresses economic, financial, environmental, and social dimensions, including transboundary impacts, with a sustainable financial approach to provide the needed funding to develop the sites.
- Incomplete dams and existing feasibility studies need to be updated to reassess the technical and economic viability of these investments.
- Large investments should be considered and analyzed within the context of overall river basin planning.

Introduction

Armenian rivers present significant annual and seasonal variability in runoff. In order to address this variability, the country has built 87 dams, with a total capacity of 1.4 billion cubic meters. With the exception of the Marmarik reservoir, which was completed in 2012, all reservoirs were built before and during the Soviet era with the objective of redistributing the river floods on a seasonal or annual basis. As indicated in "Assessment of the water resources baseline" section in chapter 2, most of the reservoirs are considered single purpose, either irrigation or hydropower. The safety conditions of more than 20 of the existing reservoirs, found to pose an imminent threat to human life, were improved under two earlier World Bank-funded projects. Photo 4.3 depicts the Arpilich reservoir.

Photo 4.3 Arpilich Reservoir

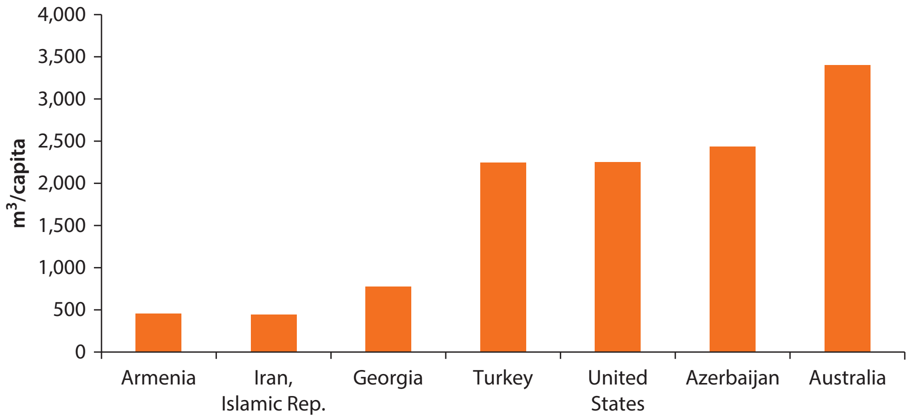
Source: Courtesy of Vahagn Tonoyan. Used with permission; further permission required for reuse.

On average, the per capita storage capacity of Armenia is about 450 cubic meters, which is considered low for a semiarid country. In comparison to its neighboring countries (figure 4.5), Armenian per capita storage is similar to that of the Islamic Republic of Iran, and represents less than 20 percent of the storage capacity of Azerbaijan and Turkey and less than 60 percent of the storage capacity in Georgia (FAO Aquastat database).

Recent Government Efforts

Regulation of surface runoff is of strategic importance to the irrigation sector in Armenia. Increasing the strategic water reserves and regulation of river flows is a key action highlighted in the National Water Program. This may be even more critical in the context of future climate change and impacts on the potential

Figure 4.5 Per Capita Storage Capacity in Armenia Compared to Its Neighbors and Other Countries



Source: FAO Aquastat database. Based on 2013 data.

frequency and severity of droughts and floods (as noted earlier). According to the Ministry of Territorial Administration, there are 157 potential reservoirs at various stages of construction, design, or planning (table 4.12). Most of the designs were completed during Soviet times. The overall storage capacity of these reservoirs is 1.72 billion cubic meters.

Of the 32 dams either incomplete or at the design stage, 3 are top priorities for the government: Kaps (incomplete), Yegvard (incomplete), and Vedi (at the design stage). In addition, 4 other incomplete reservoirs—the Apna, Karmir Guygh, Artik, and Getik—and 14 new reservoirs—the Lichk, Oshakan, Argichi, Getikvanq, Gegardalich 2, Hartavan, Khndzoreshk, Upper Sasnashen, Elpin, Khachik, Astghhadsor, Byurakan, Geghadzor, and Selav-Mastara—are priorities for the government. Table 4.13 provides a summary of the key features of these priority reservoirs.

During the past few years, the government of Armenia has tried to mobilize external funding for completing the construction of unfinished reservoirs and for updating the feasibility studies of those already designed reservoirs. So far, prefeasibility studies have started for the construction of Vedi reservoir, financed by the French Agency for Development (AFD); and Kaps reservoir, financed by KfW Development Bank (the German development bank). According to the

Table 4.12 Status of Reservoirs in Armenia

Status of reservoirs	*Quantity*	*Storage volume (MCM)*
Construction not completed	9	185.4
Designed (different stages of design)	23	733.2
Studied, preliminarily	67	452.8
Planned, but not studied	60	345.9
Total	**157**	**1,717.3**

Source: Water Design Institute of Armenia 2014.
Note: MCM = million cubic meters.

Table 4.13 Key Features of Priority Reservoirs

Reservoir name	*River basin*	*Marz (province)*	*Status*	*Total vol. (MCM)*	*Est. cost*[a] *(million US$)*
Kaps	Akhuryan	Shirak	Partially constructed; feasibility study is in progress for to 60 MCM reservoir option	60.00	44.0
Yegvard	Hrazdan	Kotayk	Partially constructed; feasibility study to be conducted	90.00	139.1
Vedi	Vedi	Ararat	Designed in Soviet times; feasibility study is ongoing; will be followed by preparation of final design for construction of dam	20.00	40.8
Apna	Kasakh	Aragatsotn	Partially constructed; final design was prepared in Soviet times	5.25	8.7
Karmir Guygh	Voskepar	Tavush	Partially constructed	8.50	33.0
Artik	Karkachun	Shirak	Partially constructed	1.69	3.5
Getik	Chichkhan	Lori	Partially constructed; preliminary design available	3.00	7.8
Lichk (Meghriget)	Meghriget	Syunik	New; preliminary design has been prepared by MCA	1.17	6.5
Oshakan (Kasakh)	Kasakh	Aragatsotn	New; feasibility study report is available	13.85	35.0
Argichi	Argichi	Gegharkunik	New dam; preliminary design is available, prepared by Millennium Challenge Corporation	5.50	4.2
Getikvanq	Elegis	Vayots Dzor	New; preliminary investigations have been implemented	23.00	54.0
Gegardalich 2	Yot Aghbyur	Kotayk	New; preliminary design is available	5.50	18.4
Hartavan	Gegharot	Aragatsotn	New; preliminary design is available	3.00	9.7
Khndzoreshk	Karkachun	Syunik	New; preliminary investigations have been implemented	5.20	13.0
Upper Sasnashen	Upper Sasnashen canal	Aragatsotn	New; preliminary investigations have been implemented	1.00	6.5
Elpin	Elpin	Vayots Dzor	New; final design is available	1.00	4.0
Khachik	Khachik canal	Vayots Dzor	New; preliminary investigations have been implemented	0.50	3.1
Astghhadsor	Astghhadsor	Gegharkunik	New; preliminary investigations have been implemented	1.25	2.3
Byurakan (Hamberd)	Hamberd	Aragatsotn	New; preliminary investigations have been implemented	2.70	8.7
Geghadzor	Geghadzor	Aragatsotn	New; preliminary design is available	1.50	6.5
Selav-Mastara	Selav-Mastara	Armavir	New; feasibility study was updated	10.20	32.0
Total				**263.81**	**480.8**[b]

Source: Water Sector Projects Implementation Unit. 2014.
Note: MCM = million cubic meters.
a. Includes design, construction, and technical supervision works.
b. 200 billion AMD.

information provided by the State Committee on Water Economy, the Japan International Cooperation Agency (JICA) and the Kuwait Fund for Arab Economic Development (KF) will likely support the preparation of Yegvard and Selav-Mastara reservoirs respectively. It should be noted that while feasibility studies for these dams are ongoing, technical feasibility has yet to be confirmed. Economic and financial costs and benefits need to be reassessed as well as the integrity of the existing works. Boxes 4.5 and 4.6 provide a few observations from a field visit to the Yegvard and Vedi construction sites.

Box 4.5 Preliminary Assessment of Yegvard Reservoir and Dam

The original dam design was for a height of 48 meters and 228 million cubic meters (MCM) in reservoir capacity. The area to be irrigated from this dam was estimated at 30,500 hectares–7,500 hectares of new irrigated land and 23,000 hectares under improved irrigation. Construction commenced in 1984 but was suspended in 1992. At present, a new proposed dam is contemplated, with a height of 32 meters and 90 MCM in reservoir capacity. The irrigated area is estimated at 11,000 hectares, of which 6,484 hectares of pumping schemes will be converted to gravity irrigation. The estimated cost is around US$87 million or 36 billion (as of 2012) Armenian drams (AMD), including construction and rehabilitation of irrigation canal networks.

According to the new design, the Yegvard dam is expected to store excess water in the Hrazdan River during the winter and supply water for irrigation in the Ararat valley areas, where water levels, pressure, and yields of groundwater in wells and springs have been declining. The Metsamor (Sevjur) River fed from springs also has shown a sharp reduction in available water for irrigation.

The proposed embankment structure design may need to be revised and optimized, considering the anticipated loads, including lower water pressure. Also, detailed geotechnical investigations are needed to assess permeability of the foundation and to propose suitable countermeasures. Currently, more than half of the estimated cost is allocated to antiseepage measures for treating the pervious reservoir floor as per the original design.

The site of the reservoir is located away from the river, and it is to be filled via the Arzni-Shamiran canal. The capacity of this canal is proposed to be increased from 16.6 cubic meters per second to 29 cubic meters per second, possibly with a second feeding canal to fill the reservoir with water from the Hrazdan River during the nonirrigation winter period. Required canal capacity and duration of reservoir filling need to be confirmed.

The potential area benefiting from irrigation is located near the Kasakh River, and a water conveyance system will have to be built. The expected benefits from the dam are increased agriculture productivity, reduction of pumping costs, and reduction of groundwater depletion. The average incremental cost is estimated at US$0.12 or 50 AMD per cubic meter (at 10 percent discount rate).[10]

A feasibility study is needed to assess the economic viability based on topographic, hydrological, geotechnical, and design works, as well as updated agronomic, economic, financial, environmental, and social studies.

Source: Ueda 2012.

Box 4.6 Preliminary Assessment of Vedi Reservoir and Dam

The Vedi dam was designed in 1991 during Soviet times. The original design called for a rock-filled dam of 90.5 meters in height and 38 MCM in reservoir capacity. The estimated area to be irrigated was around 4,000 hectares in the Ararat area. A 21.5-meter-high earth dam would need to be built in the saddle of the reservoir. As the river where the dam is to be built is very dry and seasonal, the original design diverted water from the nearby Vedi River and Khosrov River through an 8.5-kilometer diverting canal and tunnel. The flows to be transferred were estimated at 13 cubic meters per second and 2 cubic meters per second from the Vedi and Khosrov, respectively.

A revised design has been proposed, which includes a smaller dam of 70 meters in height and 20 MCM in reservoir capacity to irrigate 2,745 hectares. This will eliminate the need for a saddle dam and diversion tunnel, requiring only a canal for diversion. The construction cost is estimated at around US$35 million or 15 billion Armenian drams (AMD) (as of 2012). Thus, the average incremental cost is estimated at US$0.22 or 90 AMD per cubic meter (at 10 percent discount rate). The expected benefits from the dam are increased agricultural productivity and reduced pumping costs.

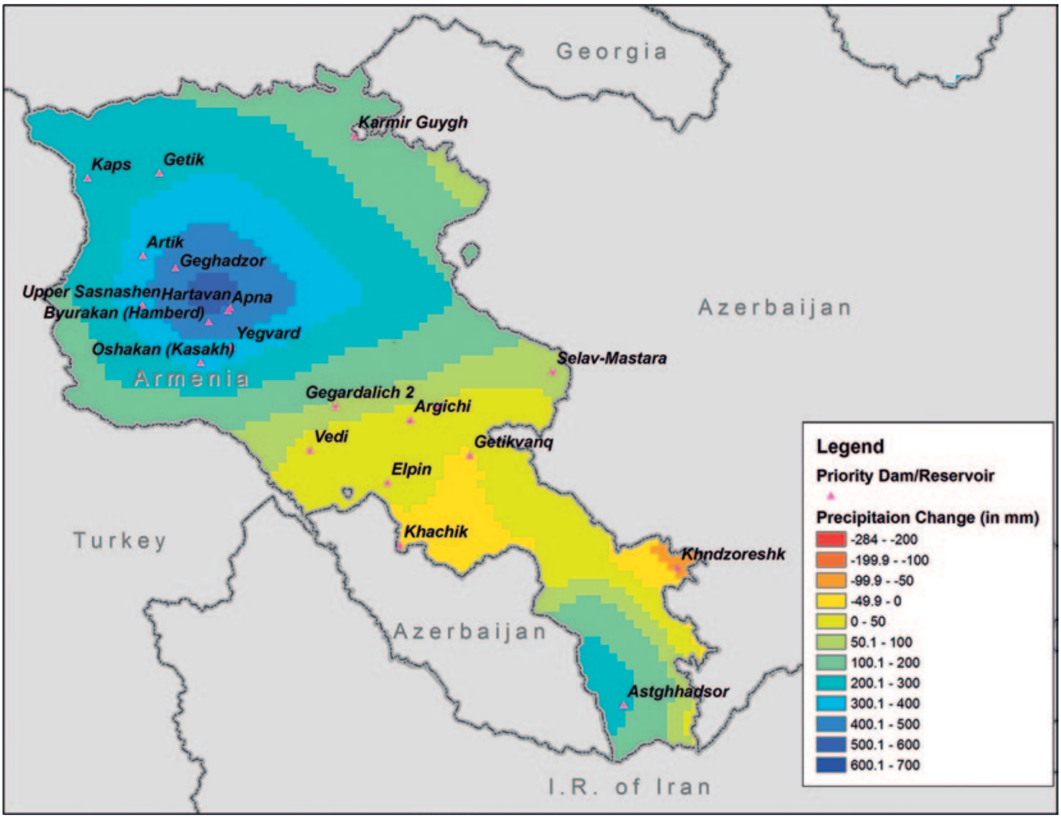
According to information received, the intake site and diversion canal route are still under consideration. Thus, a detailed topographic survey, geotechnical assessment, and updated hydrological assessment are required. The current cost seems to be an underestimate. The cost does not include rehabilitation and construction costs for downstream irrigation networks.

Source: Ueda 2012.

Based on the preliminary construction cost estimates for Yegvard, Kaps, Vedi and Selav-Mastara, and the expected volumes of water to be stored in these reservoirs, the average incremental cost of water ranges between US$0.09 or 37 AMD (Kaps) and US$0.39 or 154 AMD (Selav-Mastara) per cubic meter.[11] At this stage, it seems that the average incremental cost of water is higher than the estimated incremental economic value of water in irrigation.[12] Other economic benefits of the reservoir will have to be identified.

Three key issues that will also need to be considered during the feasibility studies of the priority dams are climate change and transboundary impacts. First, with regard to climate change, as the climate and hydrology have experienced changes since the investments were designed, it is important that the updated feasibility studies include these considerations. As shown in map 4.7, precipitation at the various dam sites has indeed changed over recent decades (on average a decrease in precipitation of about 100 millimeters). Second, with regard to transboundary impacts, as most of the rivers in Armenia are shared with neighboring countries downstream, country impacts would need to be analyzed. Third, these large investments should also be considered and analyzed within the context of overall river basin planning.

Map 4.7 Changes in Precipitation at Dam Sites, 1950–2009



Source: NASA.
Note: Period A is from 1998 to 2009, and Period B from 1950 to 2000. A full-color version of this map may be viewed at http://www.issuu.com/world.bank.publications/docs/9781464803352.

Conclusions

Storage plays an important strategic role in the regulation of variable surface runoff in Armenia. This is critical for the irrigation, water supply, and energy subsectors, particularly in the semiarid regions where rapidly growing populations are facing depletion of groundwater resources. A comparison with its neighbors shows that Armenia's per capita storage capacity is much lower (with the exception of the Islamic Republic of Iran). Though many of the earlier plans for reservoir development date back to Soviet days, an updated strategic master plan that addresses economic, financial, environmental, and social dimensions, including transboundary and climate change impacts, is missing. Moreover, many of the current incomplete dams and existing feasibility studies would need to be updated to reassess the technical and economic viability of the investments. In addition, an overall financing strategy is needed to support the proposed investments. Finally, as discussed earlier, these large investments should be considered and analyzed within the context of overall river basin planning.

Notes

1. Environmental Impact Monitoring Center: http://www.armmonitoring.am/.
2. ASHMS: http://www.meteo.am.
3. "Tendering of RBMPs for the Akhurian-Metsamor, Chorokhi-Adjaristkali and Upper Kura Basins." Environmental Protection of International River Basins Project: http://blacksea-riverbasins.net/en/tendering-rbmps-akhurian-metsamor-chorokhi-adjaristkali-and-upper-kura-basins.
4. Note that there is an incongruity with respect to mineral water (defined greater than 1 g/l) where the authority over abstraction licenses is with the Ministry of Energy and Natural Resources.
5. There are two artesian aquifers: one of pebble and sand sediments and the other of andesite and basalt rocks. According to investigations conducted in 1958–62, they are located at a depth of 38–180 meters and 25–192 meters, respectively.
6. Currently, the major export markets include Georgia, the Russian Federation, Ukraine, and the United States of America. There is potential to explore the European Union market.
7. The Parliament of Armenia revised the Law on Nature Protection and Nature Utilization Payments, which entered into force on January 1, 2014.
8. Alternative names for the rivers in this section include Kur, Kura (Georgia and Turkey), Mtkvari (Azerbaijan); Araks, Aras (the Islamic Republic of Iran and Turkey), Araz (Azerbaijan); Debed, Dobeda Chay (Georgia); Aghstev, Akstafe (Azerbaijan); Akhuryan, Arpaçay (Turkey); Vorotan, Bargyushad (Azerbaijan); Arpa, Arpa Chay (Azerbaijan).
9. Its importance centers on 100 species of migratory water birds, of which 30 species breed there, including the globally threatened marbled teal and endangered white-headed duck. This site is threatened by a decrease in water level. No management plan has been prepared yet.
10. This is calculated by dividing the present value of all incremental costs (capital, operation, maintenance, and replacement) by the discounted value of the stream of incremental volume of water produced. A 10 percent discount rate is used in the calculation and a 40-year economic life. No physical contingencies are included and the operation and maintenance costs are estimated at 1 percent of construction costs. A four-year construction period for the works is assumed.
11. The calculation assumes a four-year construction period, a 40-year economic life, and a discount rate of 10 percent.
12. Using data from the Implementation Completion and Results Report of the Irrigation Development Project funded by the World Bank, the estimated economic value of water in irrigation ranges between US$0.04 (alfalfa) and US$0.23 (apricots) per cubic meter (World Bank 2009).

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