STATE COMMITTEE OF WATER ECONOMY
MINISTRY OF TERRITORIAL ADMINISTRATION
REPUBLIC OF ARMENIA

DATA COLLECTION SURVEY
ON
AGRICULTURE AND IRRIGATION SECTOR

FINAL REPORT

DECEMBER 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

SANYU CONSULTANTS INC.

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ABBREVIATIONS

ADS	Armenia Development Strategy
ADB	Asian Development Bank
AFD	Agence Française de Developpement
ASMC	Agricultural Support Marz Center
ASRC	Agricultural Support Republic Center
B/C	Benefit Cost Analysis
CARD	The Center for Agribusiness and Rural Development
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIP	International Potato Center
CIS	Commonwealth of Independent States
CJSC	Closed Joins Stock Company
EIA	Environmental Impact Assessment
EN	Exchange of Notes
ESIA	Environmental and Social Impact Assessment
EU	European Union
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
IPGRI	International Plant Genetic Resources Institute
IRR	Internal Rate of Return
ISNAR	International Service for National Agricultural Research
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
NPV	Net Present Value
PIU	Water Sector Projects Implementation Unit
SADS	Sustainable Agriculture Development Strategy of the RA
SCWE	State Committee of Water Economy
SMEs	Small and Medium Enterprises
TIWRM	Towards Integrated Water Resources Management
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WB	World Bank
WSA	Water Supply Agency
WUA	Water User Association

Unit

mm	millimeter	m^2	square meter	m^3	cubic meter
cm	centimeter	km^2	square kilometer	MCM	million cubic meter
m	meter	ha	hectare		
km	kilometer				
g	gram	cm/s	centimeter per second	Kcal	kilocalorie
kg	kilogram	m^3/s	cubic meter per second	kWh	kilowatt hour
g/cm^3	gram per cubic centimeter	lit/sec	litter per second	Ωm	ohm meter

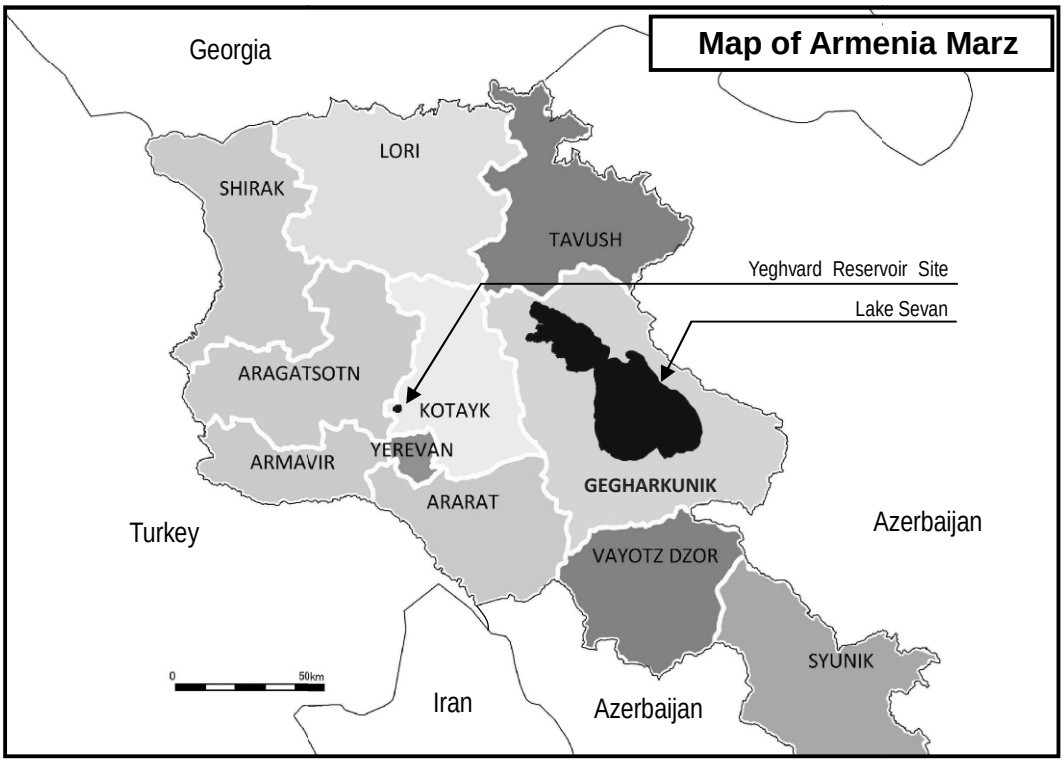
Currency

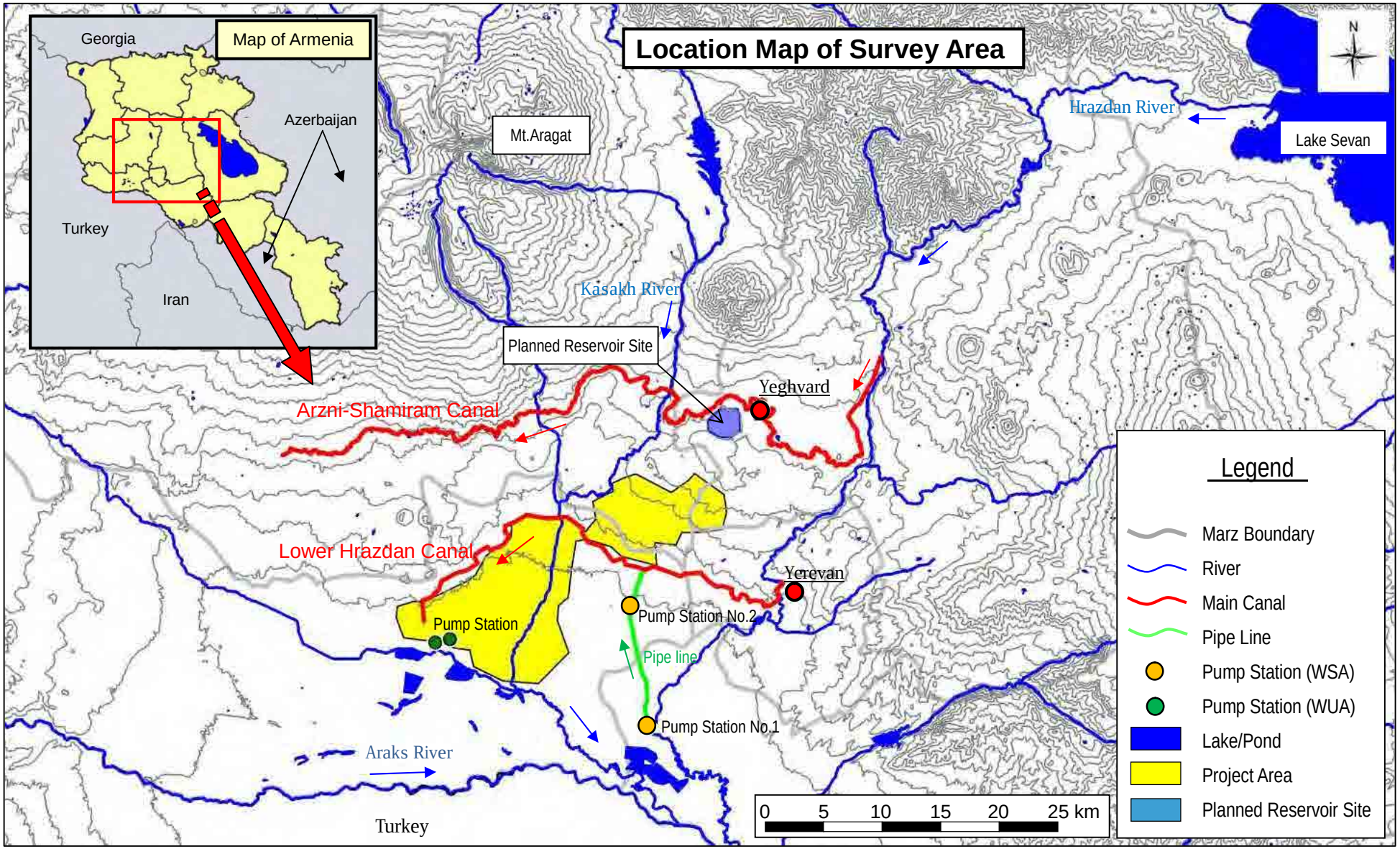
Japanese Yen	(JPY)
US Dollar	(USD)
Armenia Dram	(AMD)

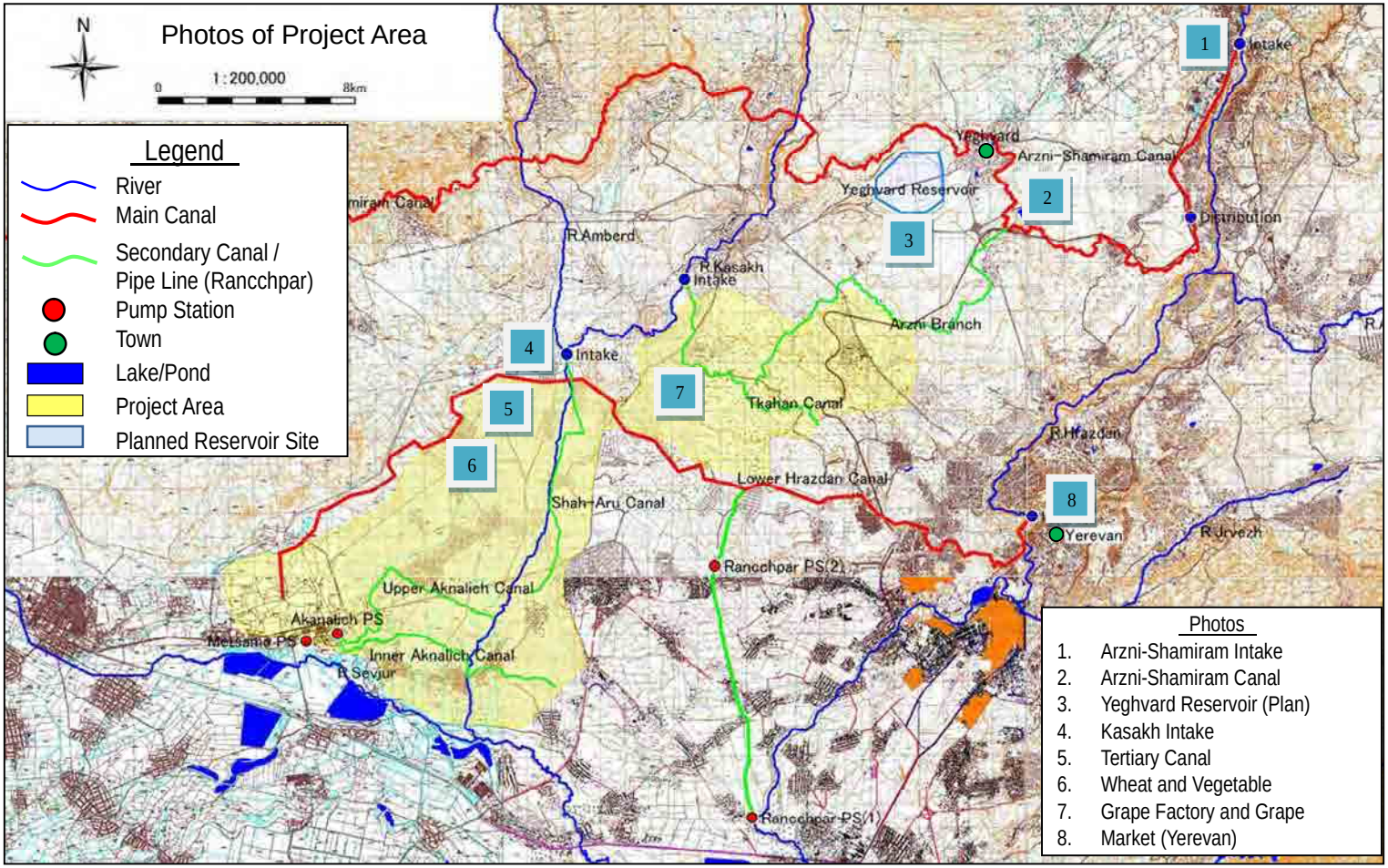
Exchange rate (OANDA rate as of 31st August 2014)

USD = 96.53 JPY

AMD= 0.2542 JPY




Location Map of Survey Area
Map of Armenia
Georgia
Azerbaijan
Turkey
Iran
Mt.Aragat
Hrazdan River
Lake Sevan
N
Kasakh River
Planned Reservoir Site
Yeghvard
Arzni-Shamiram Canal
Lower Hrazdan Canal
Yerevan
Pump Station
Pump Station No.2
Pipe line
Pump Station No.1
Araks River
Turkey
0 5 10 15 20 25 km
Legend
Marz Boundary
River
Main Canal
Pipe Line
Pump Station (WSA)
Pump Station (WUA)
Lake/Pond
Project Area
Planned Reservoir Site


Photos of Project Area
N
1 : 200,000
0
8km
Legend
River
Main Canal
Secondary Canal / Pipe Line (Rancchpar)
Pump Station
Town
Lake/Pond
Project Area
Planned Reservoir Site
Intake
Arzni-Shamiram Canal
Yeghvard Reservoir
Distribution
R.Amberd
R.Kasakh Intake
Arzni Branch
Tkahan Canal
Lower Hrazdan Canal
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R.Hrazdan
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6. Wheat and Vegetable
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1


2


3


8


7


6


5


4

CHAPTER 1 OUTLINE OF THE SURVEY

1-1 Background

1-1-1 Outline of the Republic of Armenia

The Republic of Armenia (hereinafter referred to as "Armenia") is located in the Armenian highlands in the Caucasus range with a territorial area of 29,743km^2 and a population of 3 million (as of 2013, UN Population Fund). Armenia is a landlocked country, surrounded by 4 countries, namely, Georgia in the north, Azerbaijan to the east, Iran in the south and Turkey to the west, and its altitude is averaged at 1,800m with a range of 375-4,090m. The annual mean precipitation is 600mm though it is about 300mm at Yerevan, the capital of Armenia (altitude approx. 1,000m) in the Ararat Plain.

Lake Sevan is situated in the middle of the country at 1,900m above sea level and is an important water source for Armenia by supplying water for hydropower and agriculture (irrigation) in the Ararat Valley. The storage volume of Lake Sevan was recorded at 58 billion m^3 in the 1940s; however, the volume was sharply reduced to 33 billion m^3 by the first half of the 1970s. The government of Armenia in the 1980s restricted water use for hydropower and agriculture and also implemented a plan for conserving the water of Lake Sevan by constructing a tunnel for the purpose of diverting water from the River Arpa and the River Vorotan, both located at the south of the Lake. As a result, the storage was recovered to 38 billion m^3 by the present time. The government has continued to restrict annual water use of Lake Sevan within 170 million m^3 except during the period of a drought year.

From the socio-economic perspective, soon after its independence from the Soviet Union in 1991, Armenia has pursued free economy as the national policy in spite of its unstable political/economic situation. Particularly important policies include land privatization (in 1991), support for trade promotion and a domestic service sector (in 1991-1992), industrialization (in 1995), introduction of domestic currency (in 1993), and the establishment of foreign currency and stock markets, etc., and Armenia has energetically deployed these policies for further national development. Table 1-1.1 shows major socio-economic indexes in Armenia. It indicates that agriculture is an important sector for the country by occupying around 20% of the GDP during the last 5 years.

Table 1-1.1 Major Socio-economic Indexes in Armenia

Indicator	Unit	2002	2009	2010	2011	2012
Population	million	3.0	3.0	3.0	3.0	3.0
Increase rate	%	-0.4	-0.3	-0.2	0.0	0.2
Average life	Age	72	74	74	74	74
Literacy rate (male)	%	na	na	na	99.7	na
Literacy rate (female)	%	na	na	na	99.5	na
Unemployment rate	%	27.8	18.7	19.0	18.4	18.5
GNI	USD/person	800	3,180	3,330	3,490	3,720
GDP	million USD	2,376	8,648	9,260	10,142	9,951
GDP growth rate	%	13.2	-14.1	2.2	4.7	7.2
Economic structure by GDP						
1) Agriculture	%	26.0	18.9	19.2	22.7	21.6
2) Industry	%	39.0	35.8	36.9	33.1	33.2
3) Service	%	35.1	45.3	44.0	44.2	45.2
USD exchange rate	AMD	573.4	363.3	373.7	372.5	401.8

Source: JICA HP, Major indexes (Extract)

Figure 1-1.1 shows that the working population related to agriculture occupies 38% out of the total working population of the country. Confined to the rural area (except Yerevan and Marz capitals), the population working in the agriculture-related sector is 73% of the total working population (as of 2012). Approximately 22% (6,500 thousand ha) of the nation's territory is arable land, and 2,100 thousand ha is categorized as agricultural land. Out of this, about 130,000 ha is irrigated annually (Source: Statistic Year book of Armenia, 2013).

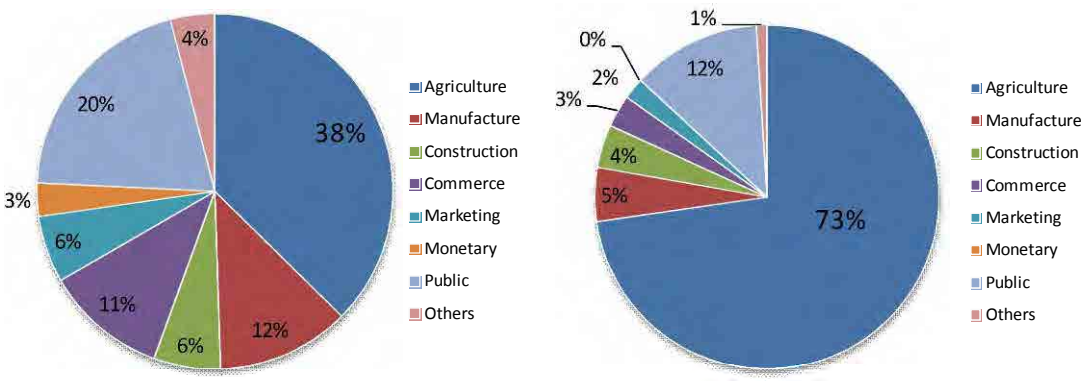


Figure 1-1.1 Labor Population Ratio by Sectors in the Country and Rural Area
(Source: Statistical Yearbook of Armenia 2013)

1-1-2 Development Plans in Armenia

As for the development strategy related to agriculture and irrigation sector in Armenia, the followings are presented: 1) Armenia Development Strategy for 2014-2025 (March 2014: ADS); 2) 2010-2020 Sustainable Agricultural Development Strategy of the RA (SADS); and 3) Towards Integrated Water Resources Management: Revisited (June 2014: TIWRM, WB).

ADS has been made by updating data from 2012 and is based on the "Sustainable Development Program for 2008-2021: SDP" which was prepared in 2008 in consideration of the negative growth of the GDP due to "Lehman Shock" which occurred in 2008. The updated ADS was finalized in 2014 by looking over some target value. ADS is targeting four (4) priority issues, which are: 1) Growth of employment; 2) Development of human capital; 3) Improvement of the social protection system; and 4) Institutional modernization of the public administration and governance based on "sustainable employment growth" as a main objective. Also, the following goals are indicated in the ADS:

1) Development of commercial agricultural organization, cooperatives and family farms integrated with market infrastructures through application of intensive technologies;
2) Stable food security of the population and meeting demands of agriculture processing raw materials through a realistic combination of food security interests and comparative advantage of external trade of agriculture and food products;
3) Increase of gross product in agriculture due to increase of labor productivity, comparative reduction of the number of people employed in agriculture and use of part of a surplus workforce in the non-agricultural sphere through agriculture service and training;
4) Promotion of agricultural processing industries that utilize small and medium-sized enterprises (SMEs);
5) Domination of production of agricultural products with high added value in the plant cultivation and improvement of animal husbandry intra-branch structure; and
6) High level of food security of the country's population, ensuring self-sustainability for basic foodstuffs and reduction/mitigation of rural poverty

SADS is regarding the agricultural strategy in Armenia, based on a threefold vision, namely: 1) Market-oriented production; 2) Sustainable increase of food production; 3) Intra-sectoral structure of livestock production, etc., and declares as goals: 1) to promote industrialization of agriculture, 2) to increase the food security level, and 3) to shape favorable conditions for promoting export-oriented

productions (Details were shown in “2-3 Agricultural Sector” in Chapter 2). Furthermore, related to agricultural infrastructure, the government of Armenia supports 1) the improvement of the irrigation system, 2) the enhancement of the operation and maintenance (O&M), 3) the establishment of a Water Users Associations (WUAs), and 4) changing to gravity irrigation system from a pump irrigation system.

ADS does not describe much about the irrigation strategy, only that the goals are 1) to invest 0.3% of the GDP for irrigation development, 2) to extend irrigated land areas and improve irrigation efficiency of existing irrigated lands, 3) to improve collecting irrigation tariff by financial support of WUAs and 4) to strengthen already formed participatory management and so on. NB: TIWRM complements the ADS irrigation strategy.

TIWRM was originally made by WB in 2002 and TIWRD -Revisited- was completed taking the latest status of water resources environment from collected data/information through the related ministries in Armenia into consideration in 2014. Though TIWRM (2014) is not a development strategy on irrigation, it stimulates future water resources management and the viewpoint of an irrigation strategy in Armenia. TIWRM is composed of 1) Integrated Water Resources Management (IWRM) Diagnostic, 2) A Decade of IWRM Reform, 3) Emerging Challenges to IWRM, 4) Donor Support to the Water Sector in Armenia and 5) Conclusions and Recommendations (Details were shown in “2-4 Irrigation Sector” in Chapter 2).

1-1-3 Policy of Japan's ODA to Armenia

To achieve the main objective of the ADS of Armenia viz. “Sustainable employment growth”, the principal policy of Japan's ODA is “to achieve balanced and sustainable economic growth” with prioritized 1) improvement of institution and infrastructure for economic growth and regional development as well as 2) strengthening of disaster prevention measures. And since donor countries other than Japan, like the USA, Germany, France, etc. and international agencies such WB, IMF and ADB are assisting Armenia, Japan pays attention to share information with other donors/agencies to display their assistants effectively without any duplications on the sector and region of Armenia. Followings are records of Japanese assistance to Armenia until 2012.

1) Japanese ODA loan (EN base):31.808 billion Japanese Yen (Approx. 300 million USD)
2) Japan's grant aid (EN base): 6.651 billion Japanese Yen (Approx. 60 million USD)
3) Technical cooperation (JICA): 2.923 billion Japanese Yen (Approx. 30 million USD)

1-2 Background and Objectives

The government of Armenia requested to undertake the so-called Kaps Project in Shirak Marz of the Government of Germany (KfW) and the so-called Vedi Project in Ararat Marz of the Government of France (AFD) respectively. Both projects are now in the end stage of a full-scale Feasibility Study (F/S) as of September 2014. And the Government of Japan has responded to a request of Armenia for a Japanese ODA loan and dispatched a JICA contact mission in relation with the Yeghvard Irrigation Project in Kotayk Marz in February 2014. In the results of a field observation, it was found that construction of a reservoir which had been designed with a capacity 228 MCM at the time of the Soviet Union had been started in the beginning of 1980 and was suspended in 1985 due to a financial deficit, and since then the capacity was reduced to 90 MCM from 228 MCM in 1999.

Based on a series of discussions with Armenian side, JICA has judged to require evaluating the possibility of the re-use of embankments, geological/hydrogeological conditions, hydrological information, farming status, target irrigation area in Yeghvard and the designed capacity of the reservoir and so on. In this survey, collection of data/information on the current state of the

agricultural and irrigation sector in Armenia related to the Yeghvard Irrigation Project was carried out in order to examine the possibility of a Japanese ODA Loan.

1-3 Contents of Survey

The following information was collected and analyzed during the survey period related to the Armenia and Yeghvard Irrigation Project:

1) Development strategy and policy of Armenia
2) International water right and trans-boundary treaty related to Armenia
3) Aid activities of Donor countries and international agencies
4) Hydro-meteorology and water resources in Armenia
5) Farming, agricultural production, marketing, trade, agricultural extension, research and training organization
6) Population, land and land institution, farmers organization including questionnaire survey and WUA workshop
7) Existing irrigation facility and planed irrigation area in Yeghvard
8) Geological and hydro-geological data in Armenia including F/S report for Yeghvard reservoir prepared in Soviet time
9) Filled embankment and reservoir bottom of Yeghvard including physical characteristic soil and permeability tests
10) Regulations of dam and seismic design, reservoir construction
11) Procedure of loan project and environmental and social impact assessment, etc.

1-4 Members of Survey Team and Periods of Their Field Survey in Armenia

Members of survey team and periods of their field survey in Armenia are shown in Table 1-4.1.

Table 1-4.1 List of Members of Survey Team

In charge	Name	Field survey period	Belonging
1. Team leader	Tetsuya YAMADA	November 3– 4, 2014	Japan International Cooperation Agency (JICA)
2. Co-team leader	Hiroaki ADACHI	June 16 – 21, 2014 November 3 – 5, 2014	Same as the above
3. Chief consultant /Irrigation Development	Kazumitsu TSUMURA	June 16 – July 2, 2014 July 24 – August 29, 2014 November 1 – 7, 2014	Sanyu Consultants Inc. (SCI)
4. Co-chief consultant /Irrigation Development /Hydrology, Water resources	Fusataka ARAKAWA	June 16 – August 29, 2014 November 1 – 7, 2014	Same as the above
5. Agricultural development	Harunobu YOSHINO	June 16 – August 29, 2014 November 1 – 7, 2014	Same as the above
6. Dam design, Groundwater	Ryouichi KAWASAKI	June 28 – August 11, 2014	Same as the above
7. Dam design, Soil mechanics	Haruo HIKI	June 28 – August 11, 2014 November 1 – 7, 2014	Same as the above
8. Seismic analysis	Toru NAKAGAWA	August 5 – 29, 2014	Same as the above

CHAPTER 2 CURRENT STATUS AND ISSUES ON AGRICULTURE AND IRRIGATION SECTORS IN ARMENIA

2-1 Armenian Ministries/Agencies Related to Agriculture/ Irrigation

The administrative system of Armenia is composed of 18 ministries as shown in Figure.2-1.1, where the State Committee of Water Economy (SCWE), the implementing agency of this survey, belongs to the Ministry of Territorial Administration. This committee consists of 1) State Agencies of the System and 2) Organizations of the System. The former takes charge of project formulation, design and construction work of irrigation development and is also responsible for the rehabilitating work of the Arpa-Seven water tunnel constructed in 1980 for the purpose of restoring the storage capacity of Lake Sevan. The latter superintends 8 Water Supply Agencies (WSAs) in the field of operating irrigation facilities, domestic water supply and the sewage water system after construction. Out of these 8 WSAs, a) Sevan-Hrazdan Jrar CJSC (Closed Joint Stock Company) and b) Akhuryan-Araks Jrar CJSC execute operation and maintenance (O/M) of the irrigation system by collecting water fees. WSAs other than these two operate and manage the domestic water supply and the sewage water system.

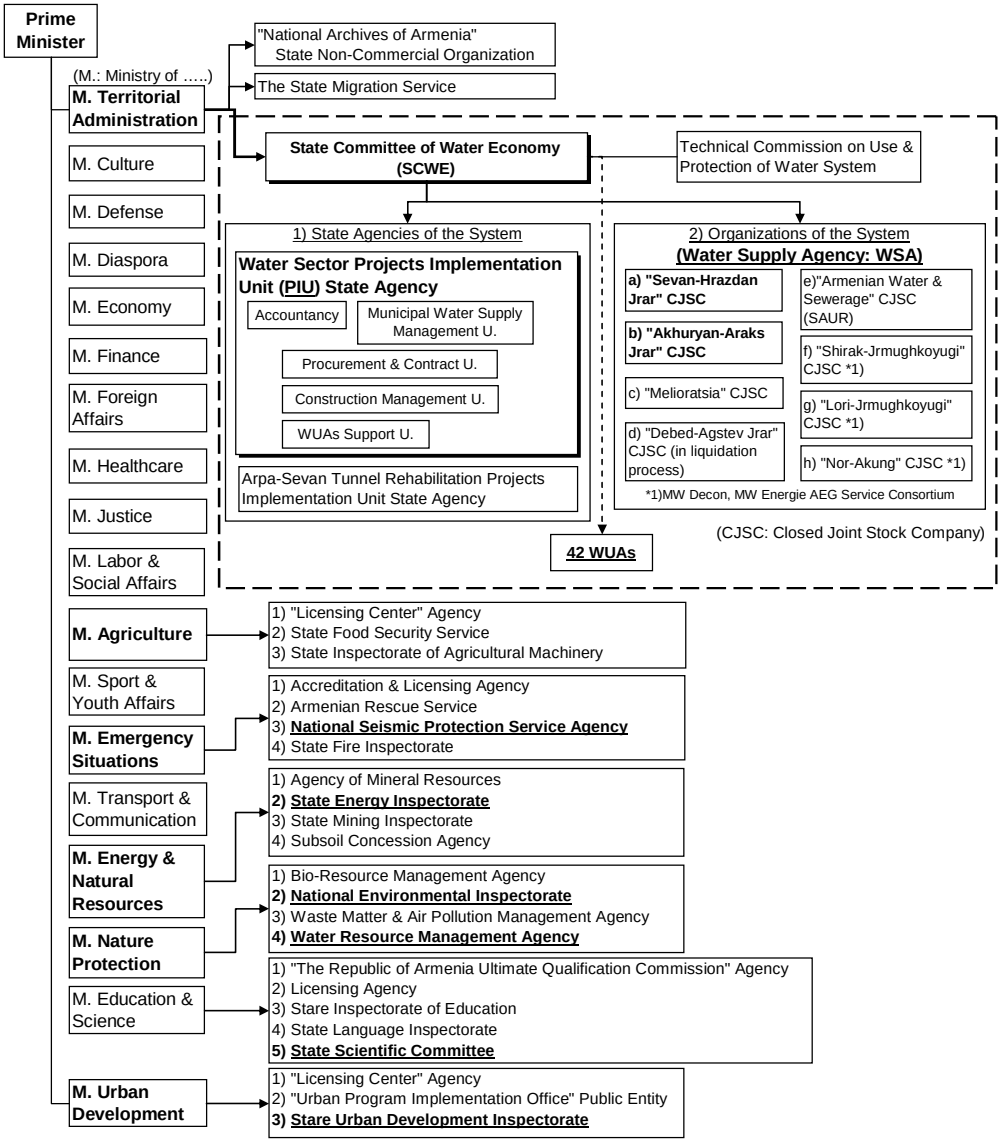


Figure 2-1.1 Administrative System of Armenia

The Water Sector Projects Implementation Unit (PIU) is the State Agency in charge of this survey and is also responsible for the Yeghvard Irrigation Project, and it is located in the above-mentioned State Agencies of the System, with a technical staff of 16 members, an administration staff of 10 members, WUA's support staff of 13 members and a clerical staff of 2 members in total staffed with 41. Other than the Yeghvard Irrigation Project, it currently handles the appraisal of the F/S contents for the Kaps Project with German (KfW) assistance and the Vedi Project with French (AFD) assistance. Major service duties of the PIU include formal actions of project implementation, more concretely, 1) formulation of working schedules required for implementing projects, project cost estimation, provision of tender documents, bidding and bidding evaluation; 2) procurement of services including construction, materials/machinery and consultants; 3) provision of construction contract documents and contract action; and 4) construction supervision, monitoring, etc.

As to related line-ministries in this survey, they include 1) the Ministry of Agriculture in charge of formulation of agricultural development policies, farming extension and assistance, research/educational organizations, 2) the Ministry of Emergency Situations that evaluates existing dams from the aspect of human and social damages in such occasions as collapse of dams, 3) the Ministry of Urban Development that is now revising standard criteria for designing earthquake seismic structures including buildings and dams, and 4) the Ministry of Nature Protection that appraises environmental and social impact assessment applied to the materialization of projects.

In addition, the Ministry of Education and Science takes charge of diversified Institutes in technical sectors. Originally, these institutes were once governmental organizations under the Communist Regime of the Soviet Union, but they were privatized into foundations after the independence in 1991 and have now become profit-making organizations.

As a related institute, four institutes are counted as follows: 1) the Armvod Proekt (Project) Institute that engaged in the F/S study of the Yeghvard Irrigation Project under the regime of the Soviet Union, later handling a wide spectrum of irrigation projects including planning/designing; 2) the Hayjrnakhagits (Water design) Institute that reviewed the F/S study of the Yeghvard irrigation project (water storage capacity: 90MCM), in 1999; 3) the Institute of Geological Science that took part in a geological survey at the time of the F/S study of the Yeghvard irrigation project and is now holding a wide range of hydrology as well as geology related information in Armenia; and 4) the Institute of Geophysics and Engineering Science which is a research institute related to seismology and also handles earthquake seismic designs for structures (located in Gyumuri, the second largest city in Armenia near the epicenter of the Spitak earthquakes).

Table 2-2.1 Trends of Annual Budget of Armenian Government

1USD= 410 AMD Unit: USD

Sector / Year	2009	2010	2011	2012	2013	2014	Percent In 2014
1. Public services	300	341	374	403	510	532	17.5%
2. Defense	365	331	357	377	446	473	15.6%
3. Safety and legal cooperation	157	138	148	150	177	201	6.6%
4. Economic relations	251	276	237	278	320	264	8.7%
5. Environmental advocacy	16	15	22	13	13	11	0.4%
6. Housing construction and municipal services	45	113	118	48	63	65	2.2%
7. Health	161	135	152	159	176	197	6.5%
8. Leisure, Culture and Religion	48	40	44	55	44	51	1.7%
9. Education	310	244	264	257	264	312	10.3%
10.Social advocacy	616	596	663	749	743	883	28.9%
11.Other	37	53	63	58	55	49	1.6%
Total	**2,306**	**2,282**	**2,442**	**2,547**	**2,811**	**3,040**	100.0%
(Increased rate based on 2009)	(Base)	(0.99)	(1.06)	(1.10)	(1.22)	(1.32)	

Source: Government of Armenia (Website)

Table 2-2.1 shows trends of the fiscal budget of the Government of Armenia. The budget for the 2014 fiscal year indicates an amount equivalent to 3 billion USD, or increased by 32% as compared to 2009 (5 years ago), thus showing steady growth from year to year. As to a sector-wise breakdown, about 29% of the total amount of the budget is allocated to Social advocacy, followed by public services expenses accounting for about 17.5%.

In agriculture sector, an amount of 17.01 million USD is allocated in 2014 fiscal year (Source: Website, Ministry of Agriculture, RA)

2-2 Natural Conditions

2-2-1 Physiography/Topography

Armenia is located in the Caucasian Region, the altitude of which is averaged at 1,800m, dominated by a mountainous topography. 77% of its entire territory lies at a high altitude ranging between 1,000-2,500m, the highest of which is Mt. Aragats, measured at 4,095m. The country has a diversified topography, including highlands, plateaus, gorges and lowlands. The watershed area of Armenia is roughly divided into Araks covering the southeastern area and Kura in the northeastern area. Fertile soils widely extend over the lowlands of the Ararat Plain, whereas they are scarce in mountainous regions at a higher altitude. Agriculture in this country has been subject to harsh climatic conditions, where most cultivated land is distributed in the areas of the elevation ranging between 600-2,500m.

2-2-2 Hydrology/Meteorology and Water Resources

Armenia experiences a continental highland climate with hot summers and cold winters. As the territory has a varied topography with numerous mountain ranges, it has 6 different climatic zones in total ranging from a dry sub-tropical type of climate to a high mountainous one. The mean annual temperature stays at 5.5 deg C, with warm summers in which the mean atmospheric temperature in July is about 16-17 deg C, while its range in the Ararat Plain reaches around 24-26 deg C. The climate in winter is characterized by severe coldness, with the mean atmospheric temperature during winter averaged at about -7 deg C. The annual precipitation amounts to more or less 600mm. The maximum annual rainfall exceeds 1,000mm in mountainous areas, but on the other hand, it is merely 200-250mm in dry areas like the Ararat Plain. Annual mean evaporation amounts to 350mm.

Major watershed areas in Armenia consist of Araks and Kura, of which the former accounts for 76% of the total watershed area and the latter accounts for 24%. These watershed areas comprise 14 sub-watershed areas in total, administratively divided into 5 watershed management groups, namely, Akhuryan, Northern, Sevan-Hrazdan, Ararat and Southern. As many as 9,500 streams and valleys are found in Armenia, the total length of which comes to around 23,000km. There are seven (7) major streams longer than 100km, which are Akhuryan, Debet, Vorotan, Hrazdan, Aghstev, Arpa and Metsamor-Kasakh. Streams in Armenia are composed of typical ones flowing along topographic formations with outstanding seasonal variability in their discharges. Streams bring floods during the Spring thaw when snow melts away, however their discharges dwindle in summer. During summer depleted discharge becomes as small as about 1/10 in comparison with the maximum discharge in the thawing season.

Over 100 lakes are found in Armenia. Among these, Lake Sevan and Lake Arpi are the most important from the aspect of size and economic significance. The Hrazdan River flows from Lake Sevan, and the Akhuryan River originates at Lake Arpi. Lake Sevan is situated at the center of the Armenian territory with its elevation of about 1,900m, known as one of the highest-altitudinal lakes in the world. It is the most important lake in Armenia for its multi-purpose use as irrigation, hydropower generation, recreation, etc. Water flows out of Lake Sevan into the Hrazdan River, where the discharge is completely kept under control for the purpose of irrigation as well as cascade-type utilization of

stream water for Sevan-Hrazdan Hydro-power generation. Lake Arpi follows it, located at the Ashotsk lowland (a depression) in the western part of the country, as high as 2,020m. The Kaps Dam, supported by German assistance, draws water from this lake.

2-3 Agricultural Sector

2-3-1 Agricultural Sector in the National Economy

The Agricultural sector in Armenia accounts for approximately 20% of the National Economy in recent years, the second largest after the service sector. The agricultural sector grows steadily (see Table 2-3.1) and its growth rate shows the highest among others sectors. The agricultural gross production in the country has decreased by 28% due to the earthquake in 1988 and the collapse of the economy's division system among former Soviet republics. The sector has recovered in 1993 through land reform, which helped establish the foundation of agricultural development despite the initial confusion.

Table 2-3.1 GDP by Economic Sectors (2011-2013)

Sector	2011 (Actual)	2012(Actual)	2013(Prelim.)
GDP (billion Dram)			
Industry	647.8	687.5	741.6
Agriculture	767.9	764.0	818.8
Construction	491.1	489.0	438.5
Services	1,458.9	1,599.0	1,761.7
Net indirect taxes	412.3	458.1	506.3
Total	3,777.9	3,997.6	4,266.8
GDP (%)			
Industry	17.1	17.2	17.4
Agriculture	20.3	19.1	19.2
Construction	13.0	12.2	10.3
Services	38.6	40.0	41.3
Net indirect taxes	10.9	11.5	11.9
Total	100.0	100.0	100.0
Growth rate (%)			
Industry	13.6	7.0	4.9
Agriculture	14.0	9.5	8.1
Construction	-12.2	3.3	-11.2
Services	4.7	6.5	5.3
Net indirect taxes	3.8	9.9	2.9
Total	4.7	7.2	3.5

Source: Armenia Development Strategy 2014-25, RA Government

In the former Soviet economy, Armenia played a role as an industrial country (the GDP ratio of the industrial sector was 44.5%). After its independence, the Armenian people focused its economic activity back to the agricultural sector. As a result, by 1993 the sector was headed for recovery and the GDP ratio of the sector grew to 46.3%. Currently, however, the GDP ratio is reduced to lower than half of that of 1993. This is not attributed to the stagnation of the sector, but rather the smooth recovery and growth of other economic sectors. The current state of agriculture in the country shows that the sector has surpassed the stage of self-subsistence and has entered the next stage of highly industrialized agriculture that includes vegetables, fruits, industrial crops and livestock, as seen in the Soviet era.

2-3-2 Agricultural Development Plan

The government launched its Sustainable Agricultural Development Strategy (SADS) covering the period of 2010-2020 and has implemented a number of related policies on this basis. SADS aims to enhance productivity and value of agricultural products in order to improve food security for the population by distributing products appropriately both to domestic and international markets and to promote its exports (targeting 3.5 times increase in the current export volume). More details of SADS are described as follows.

Vision (in 2020)

- Sustainability and competitiveness in Agriculture
- Cooperative and highly competitive, market-oriented production
- Sustainable provision of food to the population and meeting the demands of the processing industry
- Increase in gross farm produce though increasing labor productivity
- Development in SMEs in rural communities
- Positive change of intrasectoral structure of plant and livestock production
- Utilization of agricultural potential, especially land resources
- Improvement of food security for the population

Strategy goal

- Promotion of industrialization of agriculture (value-addition)
- Increase in the food security
- Shaping favorable conditions for promoting export-oriented productions

Production goals of major crops

SADS attempts to increase production of all major crops from the level of 2007 (See Table 2-3.2), with special focus on increasing production of fruits/grapes and small size livestock/poultry. Fruits/grapes are expected to be the driving force of agricultural exporting. On the other hand, livestock/poultry is seen as an import substitute, while sheep breeding is targeted to expand exporting. In addition, SADS aims to rapidly increase cultivating areas of forage crops, as a response to a high demand in forage crops from livestock promotion.

Table 2-3.2 Expected Outcomes of the Strategy (2007-2020)

Crop/Livestock	Planted Area(ha)/Heads (x 1,000)			Production (x 1,000 ton)		
	2007	2020	±(%)	2007	2020	±(%)
Cereals	176.2	190.0	107.8	452.5	662.5	147.0
Potatoes	31.6	30.0	94.9	583.9	750.0	128.4
Vegetables/Melons	31.5	31.0	98.4	1,051.6	1,357.5	129.1
Forage crops	65.0	155.0	238.5	-	-	-
Industrial crops	1.6	15.0	937.5	-	-	-
Fruits/Grapes	53.9	86.2	159.9	479.1	1,037.5	216.6
Cattle/Beef	629.1	667.0	106.0	78.6	97.0	123.4
Cows/Milk	310.6	328.5	105.8	598.9	850.5	142.0
Pigs/Pork	86.7	210.0	242.2	20.4	24.0	117.6
Sheep & Goats/Mutton	637.1	1,550.0	243.3	15.5	46.5	300.0
Sheep & Goats/Milk	-	-	-	42.3	123.7	292.4
Sheep & Goats/Wool	-	-	-	1.277	3.560	278.8
Poultry/Meat	4,018.2	8,000.0	199.1	7.8	16.0	205.1
Poultry/Egg	-	-	-	545.4 mil. pcs	750.0 mil. pcs	137.5

Source: 2010-2020 Sustainable Agricultural Development Strategy, RA

Strategies of regional promotion

SADS specifies agricultural strategies in respective Marzes. Table 2-3.3 shows the development strategies of three Marzes: Aragatsusotn, Amarvir, and Kotayk which are targeted as areas of the Yeghvard irrigation projects.

Table 2-3.3 Agricultural Development Strategy of Concerned Marzes

Marz	Current Situation	Prospective Situation
Aragatsusotn	Dairy-and-meat cattle breeding; potato and fruits production; and cereals farms	Dairy-and-meat cattle breeding; fruits and potato production; sheep breeding; and fodder production
Amarvir	Vegetable production; cereal farms; grapes production; meat-and-dairy cattle breeding; potato and fruits production	Production of grapes, vegetables and fruits; dairy cattle breeding: early ripe potato production
Kotayk	Meat-and-dairy cattle breeding; vegetable and potato production; and cereals farms and fruits production	Meat-and-dairy cattle breeding; poultry farming: fruits production; cereals farms; vegetable production; and fodder production

Source: 2010-2020 Sustainable Agricultural Development Strategy, RA

The promotion of animal husbandry, including forage crops, is a major strategy in the Aragatsusotn Marz as well as cropping of fruits and potatoes. In the Amarvir Marz, the present major crops such as vegetables, grapes and other fruits will be promoted as well as dairy industries and early varieties of potatoes. In the Kotayk Marz, the livestock and chicken industry including forage crops and diversification of agriculture with the combination of cereal crops, vegetables, and fruits will be prioritized for promotion.

2-3-3 Land Use and Cultivating Areas

The total area of the country is 2,974,300 ha (2,970 km^2) of which approximately 2,100,000 ha (around 70% of the total area) is agricultural land. However, most of the agricultural lands are classified as pastures for grazing, and hayfields mainly located in hilly areas. Actual arable land and perennial crop land totals only around 500,000 ha. Recently, the total area of agricultural land has decreased, mainly due to the decrease in pastures and hayfield areas. Appendix C-1 shows the change of land use from 2008-2014.

2-3-4 Demographic Change and Labor Forces Engaged in Agriculture

It is reported that the population of the country has been decreasing since the 1990s (the population in 1991 was reported as 3,450,000) and the slight decrease is still continuing. Several factors can be attributed to this trend such as 1) excess number of transmigration, 2) decrease in birth rate, and 3) increase in mortality rate.

In terms of the labor force engaged in agriculture, while it follows a decreasing trend, it still accounts for 40%, the largest in the total employed population (See Table 2-3.4).

Table 2-3.4 Labor Force in Armenia by Sectors (2008-2012)

Economic Sector	2008	2009	2010	2011	2012
Working Labors (thousand)					
Agriculture & forestry	**493.5**	**496.5**	**457.4**	**457.4**	**437.2**
Industry	127.6	115.1	120.7	128.8	138.4
Construction	60.4	49.5	85.8	67.4	69.1
Trade & public catering	125.6	116.7	128.4	123.9	129.9
Transport & communication	51.6	53.8	70.6	65.8	73.9
Other services	258.9	257.8	322.3	331.8	324.3
Total	1,117.6	1,089.4	1,185.2	1,175.1	1,172.8
Working Labors (%)					
Agriculture & forestry	**44.2**	**45.6**	**38.6**	**38.9**	**37.3**
Industry	11.4	10.6	10.2	11.0	11.8
Construction	5.4	4.5	7.2	5.7	5.9
Trade & public catering	11.2	10.7	10.8	10.5	11.1
Transport & communication	4.6	4.9	6.0	5.6	6.3
Other services	23.2	23.7	27.2	28.2	27.7
Total	100.0	100.0	100.0	100.0	100.0

Source: Statistical Yearbook of Armenia, National Statistical Service of RA

The agricultural labor force population was around 180,000 in 1988. After Armenia's independence, the population increased to 500,000 in 1994, and peaked at 570,000 in 2000. However, the population began to decrease since then. Given the growth in other economic sectors, labor forces who engaged in the agricultural sector during the time of independence may shift to other sectors. For this reason, the labor force in the agricultural sector may continue to decline. The decreased number of the agricultural labor force is able to drive the intensification of the agricultural land. To do so properly, the government needs to guide land policy in order to conserve the agricultural land and its adequate liquidity.

2-3-5 Land System and Scales of Farm Management

Since the independence in 1991, the comprehensive land reform was implemented. In particular, the land was allocated to each household based on the number of family members in accordance with the concerned land laws and regulations, and the private ownership of land was approved, except for foreigners. In 1994, the sale of land was also permitted. A series of reforms demised Kolkhoz and Sovkhoz while giving rise to small-scale farmers and emerging farmers. Grazing land however, is still state-owned or publicly owned.

In addition, the Land Code of the Republic of Armenia (4th July, 2001) clarified the land classification and regulation by the government as well as land-related rights including right to ownership, the right to inheritance, security interest and right of lease. These reforms function to control the land-related rights along with land characteristics for public interest.

Those who became farmers through the land reform were small-scaled, which contributes to low productivity, one of the significant agricultural problems of the country. A report even says that an average farmland per farmer is less than 1 ha. Most agricultural households as a unit possess several lands, i.e. ownership by the married couple and their children (with an average of 3.7 ownerships per household). Therefore, each household has larger lands collectively while each rightful owner has a small unit of land. As such, the study team estimates that the size of each household is not necessarily as small as the general understanding.

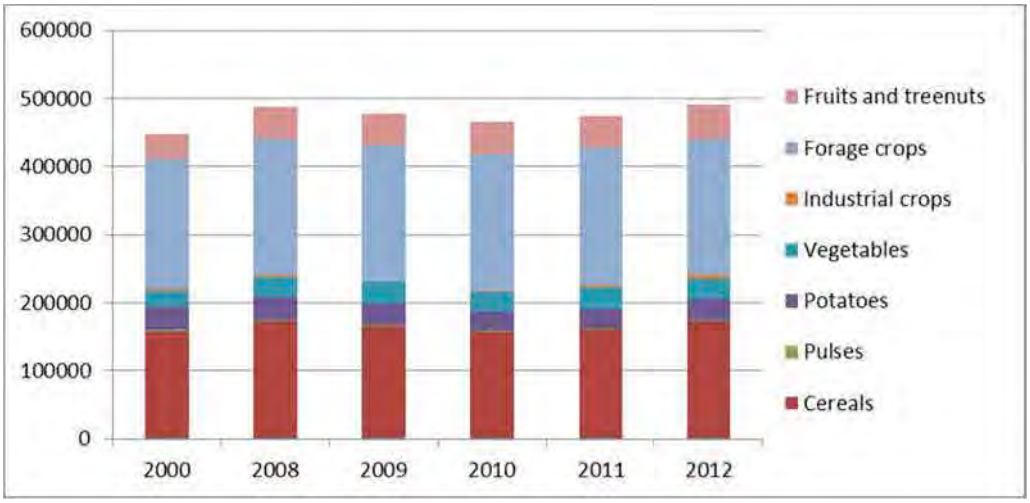
Appendix C-3 describes the number of agricultural households and their farmlands area in respective Marzes as of January, 2006, prepared by the Ministry of Agriculture.

2-3-6 Agricultural Production

1) Production of crops

a. Crop-wise overview

Appendix C-4 - C-6 show an overview of major crop production in Armenia in 2000 and from 2008 to 2012, including harvested areas, production, and yield per area (ha). In recent years, the harvested area of the country fluctuated between 470,000 and 490,000 ha. In particular, that of cereals and forage crops account for approximately three quarters of the area (See Figure 2-3.1).



Source: The JICA Study Team (based on FAOSTAT)

Figure 2-3.1 Harvested Area by Crop Groups (ha), 2000 & 2008-2012

The harvested area of major crops increased by 10% compared with that in 2000. Notably, the areas for vegetables, fruits and industrial crops (sugar beet) have expanded while that of beans and potatoes decreased (See Table 2-3.5).

Table 2-3.5 Index of Harvested Area by Crop Groups (100 = 2000)

Crop Group	2000	2008	2009	2010	2011	2012
Cereals	100	109	105	99	101	109
Pulses	100	109	101	93	96	99
Potatoes	100	100	94	83	84	91
Vegetables	100	127	128	119	131	129
Industrial crops	100	84	35	82	163	181
Forage crops	100	105	105	105	105	105
Fruits and tree-nuts	100	127	128	131	130	139
Total	**100**	**109**	**107**	**104**	**106**	**110**

Source: The JICA Study Team (based on FAOSTAT)

Irrigation is a significant infrastructure supporting the country's agriculture. It is reported that approximately 80% of domestic agricultural production was from irrigated land. The area of irrigated land is around 130,000 ha, which shows that more than one quarter of major crops are grown on irrigated land. In the areas with relatively favorable rainfall, cereals and forage crops are cultivated without irrigation, but nearly 100% of other crops are grown on irrigated land. As Appendix C-7 shows, the supply of irrigated water is proportional to the harvested area per year.

In terms of crops, it can be said that the agricultural structure tends to return to that of the previous days before the independence. In the Soviet era, Armenia specialized in vegetables, fruits and grapes because of their favorable climatic conditions. Most of these products were supplied to the Soviet Union. Animal husbandry was also promoted in Armenia, utilizing forage cereals and compound feeds supplied by other republics. The current agricultural structure in the country seems to restore this old structure of specialization.

b. Region-wise overview

This section analyzes the agricultural condition in related Marzes, based on the data provided by the Ministry of Agriculture (See Appendix C-8).

Wheat, a staple food, is cultivated all over the country. The two major production areas are the Gegharkunik and Shirak Marzes. In both Marzes, potatoes and forage crops were also well grown. The

combination of food crops and livestock are widely practiced. On the other hand, vegetables including melon and fruits including grapes are concentrated in the Ararat and Armavir Marzes, called as the Ararat plain. The Ararat plain has plenty of sunshine, relatively higher temperatures and a lower amount of rainfall. As such, the agro-climate in the area is strategically maximized as a production area for vegetables and fruits. Farm sizes in Ararat and Armavir are the smallest in the country, but farmers are relatively richer because of the high profitability of vegetables and fruits. Farmers in these two Marzes actively apply new technologies, including greenhouses or drip irrigation, which makes the area an advanced agricultural region. In addition to vegetables and fruits, all crops in the two Marzes record a higher yield (partly because rain-fed farming, and low-productive farming in general, is hardly practiced in this area due to the agro-climate condition).

As mentioned earlier, each region has its own specialization structured from the Soviet era. The Soviet Union constructed a division of economic activities in the whole Union, where the agricultural sector was relatively well structured based on the principle of "right crop for right land."

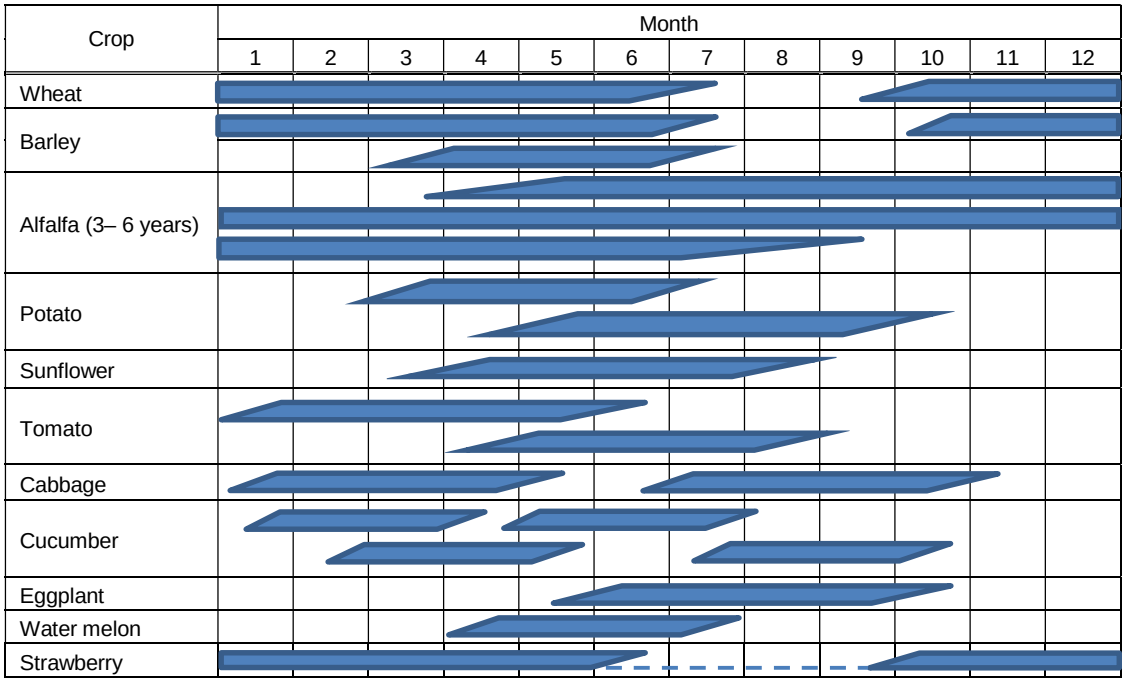
2) Animal Husbandry

Appendix C-9 - C-17 shows the number of livestock and production of edible meat, milk, eggs in respective Marzes prepared by the Ministry of Agriculture.

The number of beef cattle and milk cows has steadily increased. In 2013, the number of cattle reached to 678,000 and milk cows to 310,000. The major production areas for those animals are in Gegharkunik, Shirak, Aragatsotn and Lori, where cereals, potatoes and forage crops are produced as well. In addition, the number of bred sheep/goats also increased to 718,000 in 2013. The sharp increase of the animals can be seen especially in the Syunik Marz since this particular Marz has a border with Iran. The close proximity with Iran facilitated the increase in supply of sheep to Iran. Generally, Marzes that have a large number of sheep/goats tend to possess a large number of cattle/cows. However, in the Ararat plain (Ararat and Armavir), there is a plentiful number of sheep/goats in spite of there being a smaller number of cattle/cows. The number of pigs, about 140,000 in 2013, is the smallest among major livestock. In terms of poultry, the number significantly decreased in 2010, but it has gradually recovered by 3,944,000 since. The number of poultry in Armavir and Kotayk is outstanding. However, since 2012, the number of poultry in the Kotayk Marz has been sharply decreasing while in the Armavir Marz it has been dramatically increasing.

2-3-7 Cropping Calendar

Temperature and rainfall significantly determine cropping seasons of major crops in Armenia. Figure 2-3.2 indicates the cropping seasons of major crops based on the farm-household survey conducted by the JICA study team. Mainly, the farming of most crops begin in April or May and ends in September or October. Rainfall increases as the Spring season starts in most areas in Armenia. Wheat is an exception since it is widely sowed in autumn. In any case, the farming system in Armenia is designed based on timing with appropriate climate.



Source: The JICA Study Team (based on Farm-household Interview Survey)

Figure 2-3.2 Crop Calendar of Major Crops in Armenia

A country like Armenia that does not have a sufficient amount of rainfall requires irrigation for stable farm management. However, rain-fed farming of wheat or forage crops, which require relatively small amounts of water, is practiced in mountainous areas due to the relatively larger amount of rainfall. The areas where cereal farming and cow/cattle breeding are widespread such as Gegharkunik, Shirak, Aragatsotn and Lori extend in the rain-fed farming areas. On the other hand, on the Ararat plain, where the average temperature is relatively higher and Spring comes earlier, irrigation is required for growing all crops due to the lack of rainfall. In Ararat, vegetables are widely grown in greenhouses or tunnels between January and April.

2-3-8 Food Security

Table 2-3.6 shows the recent food self-sufficiency ratio in the country. It is difficult to define the adequate food self-sufficiency ratio from the viewpoint of national food security. However, it can be said that the self-sufficiency ratio of basic foods such as cereals, edible oils and meats are at a lower level. On the contrary, other foods like vegetables and fruits/grapes show a relatively high rate.

As Table 2-3.6 shows, foods that reached the level of self-sufficiency (higher than 95%) are potatoes, vegetables, fruits, eggs, and meats of sheep/goat. The ratio of sugar sharply increased in 2012 mainly because the production of sugar beet increased and sugar processing factories were developed. The self-sufficiency ratio of beef and milk is relatively high. However, it is evaluated that the production base of beef and milk is vulnerable to maize, a main feed for cow/cattle, which has a remarkably lower self-sufficiency ratio.

Table 2-3.6 Self-sufficiency (%) of Major Foods (2010-2013)

Food	2010	2011	2012
Wheat	33,5	36,5	32,9
Maize	20,8	26,5	32,6
Potato	100,2	98,2	99,0
Vegetable	98,3	98,2	99,3
Fruit and cherries	79,8	90	96,1

Grape	101,1	101,4	102,6
Legume crops	41,7	47,3	56,0
Vegetable oil	4,1	2,8	9,1
Sugar	24,6	43,9	93,1
Eggs	99,2	94,1	99,5
Milk	87,0	82,9	83,1
Beef	85,1	78,4	81,6
Pork	41,1	43,3	38,3
Sheep and goat meat	100,0	100,0	100,0
Chicken meat	12,4	12,2	19,1

Source: The Ministry of Agriculture, RA

SADS emphasizes domestic food security as a strategic pillar. Taking the given circumstances into consideration, a rise in cereals production and promotion of animal husbandry through an increase in forage crops must be the main strategy. Nevertheless, since major cereals and forage crops are internationally commercialized, it is inevitable to rely on cheap import commodities in order to pursue economic efficiency. SADS envisions maximizing the limited agricultural land and enhancing productivity. To achieve these central propositions for the country's agricultural development, it is crucial to keep a careful balance between the improvement of the food self-sufficiency ratio and economic efficiency.

As shown in Appendix C-18, per capita calorie supply was 2,800 kcal per day in 2011, while it was about 2,200 kcal per day in 2000. The total calorie supply has remained at a reasonable level during recent years. It is evaluated that a sufficient amount of food is supplied to the population at a national level. With regard to the breakdown, the calorie supply from animal products is increasing, while the supply from vegetable products has been gradually decreasing since 2006. It is estimated that the total supply continues at the present level, and the trend of an increasing supply from animal products and a decreasing supply from vegetable products will also continue in the near future.

2-3-9 Export and Import of Agricultural Products

1) Volume of trade

Since Armenia's independence, the government has promoted the agricultural sector with some success. However, as mentioned above, most production of agricultural crops cannot meet domestic needs; the country still heavily depends on imported products.

As Table 2-3.7 shows, wheat is the most imported product. While wheat is regarded as a major staple food, it has a low self-sufficiency ratio as demonstrated by the country's unceasing importation of wheat. Because wheat is less profitable, it cannot be considered as a priority crop in terms of effective land utilization. An increase in wheat production is a key to improve domestic food security as stipulated in SADS. The current situation, however, necessitates that wheat is continuously imported to meet domestic demand.

Sugar is the second most imported commodity. As such, the government promotes the increase of sugar beet production. In addition to forage crops such as maize and barley, a great amount of meats are also imported. Given this background and current import pattern of Armenia, it is understandable why SADS highlights the enhancement of the production of forage crops and the promotion of livestock. Among meats, poultry meat (mostly chicken) is the most imported product. Imported fruits likewise show a high import volume but they are probably tropical or semi-tropical fruits which the country is unable to produce. Imported vegetables are seen only during the limited season of winter (January-March) when there is no domestic production.

Table 2-3.7 Import of Agricultural Products (2007-2011)

(x 1000 ton)

	Food Commodity Import	2007	2008	2009	2010	2011
1	Wheat and products	519	342	390	360	383
2	Barley and products	6	5	7	34	19
3	Maize and products	80	66	48	49	52
4	Rice (Milled Equivalent)	25	14	10	11	9
5	Pulses	6	4	4	7	6
6	Potatoes and products	6	5	1	3	10
7	Tomatoes and products	0	0	0	0	0
8	Onions	6	5	5	8	11
9	Other vegetables	6	7	5	8	7
10	Apples and products	2	3	2	3	4
11	Grapes and products	3	2	4	4	3
12	Other fruits	41	36	31	41	41
13	Beef meet	8	20	14	8	12
14	Pig meat	12	22	16	15	18
15	Mutton & Goat Meat	0	0	0	0	0
16	Poultry Meat	27	37	28	36	38
17	Eggs	0	0	0	1	2
18	Milk - Excluding Butter	37	23	29	29	31
19	Alcoholic Beverages	19	22	13	18	18
20	Sugar & Sweeteners	100	118	75	115	100
21	Vegetable Oils	36	36	38	34	34

Source: FAOSTAT

Table 2-3.8 shows the major exporting crops in Armenia. Both the number of exporting commodities and volume are limited. Alcoholic beverages are the highest exported commodity. Alcoholic beverages are mainly composed of brandy made from grapes, which is one of the three most exported goods from Armenia. Evidently, there is no proven farm product for export except for fruits/grapes including processed products in the country. Vegetables show excess of imports over the small amount of exports every year although the balance is changeable year to year.

Table 2-3.8 Export of Agricultural Products (2007-2011)

(x 1000 ton)

	Food Commodity Export	2007	2008	2009	2010	2011
1	Wheat and products	0	0	0	0	0
2	Barley and products	0	0	0	0	0
3	Maize and products	0	0	0	0	0
4	Rice (Milled Equivalent)	0	0	0	0	0
5	Pulses	0	0	0	0	0
6	Potatoes and products	0	0	1	2	0
7	Tomatoes and products	12	7	2	1	2
8	Onions	0	0	0	0	0
9	Other vegetables	1	1	1	3	3
10	Apples and products	0	4	4	3	4
11	Grapes and products	6	0	4	7	7
12	Other fruits	5	9	12	5	11
13	Beef meet	2	1	0	0	0
14	Pig meat	0	0	0	0	0
15	Mutton & Goat Meat	0	0	0	0	0
16	Poultry Meat	0	0	0	0	0
17	Eggs	0	0	0	0	0
18	Milk - Excluding Butter	5	4	3	4	4
19	Alcoholic Beverages	36	38	23	30	39
20	Sugar & Sweeteners	0	0	0	3	4
21	Vegetable Oils	3	0	0	0	0

Source：FAOSTAT

Appendix C-20 and C-21 show the import and export value of agricultural products by commodity category.

2) Competitiveness of agricultural products from Armenia

"Shaping favorable conditions for promoting export-oriented productions" is one of the three strategic goals of SADS. This section examines the competitiveness of vegetables and fruits, based on the collected information from private traders.

The above data on imports and exports indicate that fruits/grapes have a certain level of competitiveness. It is not the same, however, for vegetables. According to private traders, most vegetables and fruits are exported to Russia, followed by the Commonwealth of Independent States (CISs), such as Georgia, the Ukraine, and Belarus (Iran and Turkey may be importing from Armenia also, including through unofficial channels). Table 2-3.9 indicates major exports of vegetables and fruits and competing countries in the Russian market.

Table 2-3.9 Exported Vegetables/Fruits and Competitors in Russian Market

No.	Commodity	Competitors
1	Apricots	Turkey, Uzbekistan
2	Cherries	Iran, Uzbekistan, Turkey
3	Grapes	Turkey, Moldova, Uzbekistan
4	Peaches	Azerbaijan, Turkey, Uzbekistan
5	Apples	Iran, Georgia, Russia (domestic products)
6	Plums	Uzbekistan, Serbia
7	Pomegranates	Iran, Uzbekistan
8	Tomato (greenhouse)	Turkey
9	Cucumber (greenhouse)	Iran, Turkey, Azerbaijan
10	Potatoes (open-field)	Kyrgyzstan, Russia (domestic products)
11	Cabbages (open-field)	Russia (domestic products)
12	Herbs	Uzbekistan, Azerbaijan, Israel

Source: The JICA Study Team (based on the Market Survey)

Export destinations are dominated by traditional markets, mainly because of the strength of the Armenian brand established during the Soviet era, which remains in high demand. This is particularly evident with Armenian fruits. The well-established relationship between Armenia and its traditional markets, on the downside, has kept the country from exploring new markets after its independence. The dependency on a few markets, in this case, Russia, creates a vulnerable trade structure. For this reason, it is essential to exploit new markets with a long-term perspective. Geopolitically speaking, the European Union (EU) is a promising market alternative. However, there are a number of challenges to tackle that include strict quality regulation, food hygiene (security and safety) and stable supply of diverse products in order to export the country's products to the EU market. A mid- to long-term comprehensive engagement is necessary, not only by individual farmers but also by the nation as a whole.

2-3-10 Agricultural Inputs

1) Agricultural inputs use

Table 2-3.10 shows the situation of agricultural inputs use in the country based on the result of the farm-household survey carried out by the JICA study team (Appendix-A). Although some inputs for livestock such as artificial insemination are not widely used in the area, most of the agricultural inputs for crop production are commonly used by farmers.

Table 2-3.10 Agricultural Inputs Use by Farmers

Agricultural Inputs	Condition
Seeds (purchased seeds)	Purchased seeds of vegetables and potatoes are commonly used. Some subsidized wheat seeds, other cereal seeds and forage crop seeds are sold by the governmental assistances.
Organic Fertilizers	Broadly utilized for the profitable crops such as vegetables, potatoes and fruits.
Chemical Fertilizers	Generally used for all crops. Subsidized fertilizers are sold by the government assistance program
Fungicides (Agrichemicals)	Most farmers are using for potatoes, vegetables and fruits, but divided situation for other crops.
Insecticides (Agrichemicals)	Not used for cereals except for wheat, but widely used for other crops.
Herbicides (Agrichemicals)	Though not to the extent of insecticides, widely used for almost all crops.
Agricultural Machinery	Widely used for cereal cultivation, but there are many farmers who are not using for other crops.
Artificial Insemination	Most farmers are not using
Forage (purchased forage)	Utilization of purchased forages are still limited
Vaccination	Broadly prevalent among livestock farmers except for poultry
Veterinary Drug for Livestock	Same as above
Hormone Drug for Livestock	Usages are limited

Source: The JICA Study Team (based on the Farm-household Survey)

2) The government assistance programs

The distribution of agricultural inputs in Armenia is basically liberalized, and farmers are purchasing agricultural inputs through private dealers. On the other hand, some seeds (cereals and forage crops), fertilizers and diesel fuel for agricultural machinery are sold by the government assistant programs with subsidies. Regarding the fertilizers, it seems that a certain share of domestic demands is covered by the government assistance program. Besides, the government has also played a significant role in the procurement and distribution of agricultural machinery. Even today, the government intervention in the procurement and provision of agricultural inputs performs an indispensable function in Armenia.

a. Seeds

Subsidized seeds of wheat, barley, maize, alfalfa and sweet clover are sold to farmers under the government assist programs. In terms of wheat seeds, the Seed Agency, under the Ministry of Agriculture, distributes the propagated seeds from imported basic seeds. Appendix C-22 shows the distribution of seeds by the government programs in 2013.

b. Fertilizers

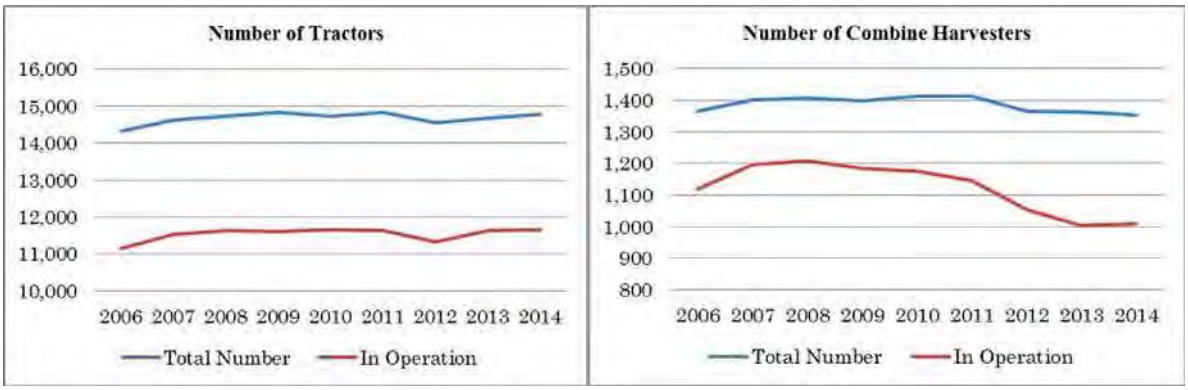
Ammonium nitrate (nitrogen fertilizer), double superphosphate (phosphate fertilizer) and potassium chloride (potash fertilizer) are sold to farmers with government subsidies. Appendix C-23 shows the distribution of fertilizers by the government programs in 2014.

c. Tractors

According to the provisional calculation, only one tractor is in operation for about 30 farmers. Therefore, it seems that there are a number of farmers who cannot use the machine effectively when they want to use it. In fact, many farmers claim that the insufficient amount of agricultural machinery is one of serious issues of their farming. The government tackled such issue to procure agricultural machinery from 1997 to 2010 by utilizing overseas assistance, including Japanese 2KR. According to the Ministry of Agriculture, the government itself has procured approximately 220 tractors in addition to the foreign assistance, and distributed them with favorable conditions to farmers. Also, 467 tractors will be allocated to Agricultural Support Centers and Unions of Pasture Users which are established in each Marz, by a new government supporting program from 2010 to 2014.

3) Agricultural machinery

Most farmers are utilizing agricultural machinery mainly for cereal cultivation. This section will describe the actual usage situation of typical machinery: tractor and combine harvester.



Source: The Ministry of Agriculture, RA

Figure 2-3.3 Numbers of Tractors and Combine Harvesters in Armenia (2006-2014)

Figure 2-3.3 indicates the total number and in operation number of tractors and combine harvesters in the country from 2006 to 2014. In recent years, the total number of tractors has tended to increase slightly, counting about 14,800 units in 2014. However, the numbers of operational tractors are always at around 78 -79% of the total numbers every year, and an actual number of tractors in operation are about 11,600 units. Besides, the number of operational combine harvesters has been sharply falling in recent years, and it seems that decrepit machinery is now a serious problem. In 2014, only about 1,000 units of combine harvesters are in operation. Those machines are privately owned, and the owners are providing a machinery service to neighboring farmers. Although an appropriate number of agricultural machinery is in operation against the estimated farmland area in Armenia on calculation (See Appendix C-24), many farmers recognize that the agricultural machinery deficit is a significant issue for them.

2-3-11 Distribution of Farm Products and Farm Gate Price

1) Distribution of farm products

Farm products are classified into two categories for personal consumption (including gift and barter exchange) and for market sales. Table 2-3.11 shows both the ratios of marketed farm products and personally consumed farm products.

Table 2-3.11 Marketing of Major Agricultural Products

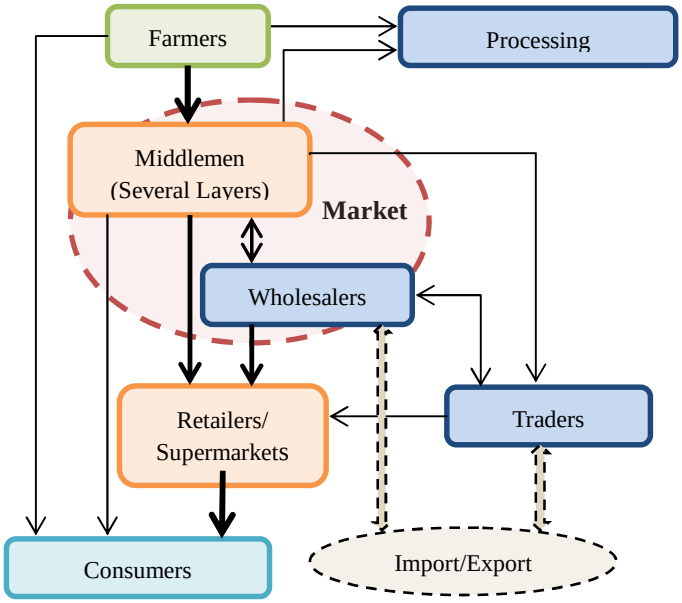
Agricultural products	Selling (%)	Personal Consumption and others (%)	Total (%)
Cereal and legume crops	21.9	78.1	100
Potato	38.0	62.0	100
Vegetable	71.3	28.7	100
Melons	84.2	15.8	100
Fruit and berries	58.0	42.0	100
Grape	76.5	23.5	100
Meat	80.9	19.1	100
Milk	44.7	55.3	100
Eggs	37.8	62.2	100
Wool	26.2	73.8	100
Honey	49.7	50.3	100

Source: The Ministry of Agriculture, RA

Cereals, potatoes, eggs and sheep wool are mainly consumed by producers themselves in the country. On the other hand, a comparatively high percentage of vegetables (including melon), fruits (including grapes) and meats are marketed. These commodities are recognized as cash products and they are important cash income sources for farmers.

The government has a policy to promote export-oriented agricultural products including vegetables and fruits as one of the main pillars of SADS. Majorities of the target irrigation area of this Project extend in the major producing area of vegetables and fruits in the country. The actual situations of vegetables and fruits distribution in the Project area are described below.

Figure 2-3.4 shows the typical distribution channels of vegetables and fruits according to interviews with famers and traders in the Project area.



Source: The JICA Study Team (based on collected information)

Figure 2-3.4 Distribution Channel of Vegetables and Fruits

a. Farmers

Many farmers sell their products to the middlemen at the farm-gate. Regarding grape producers, they tend to sell their products directly to the neighboring processing company. Organized cooperatives or group marketing by farmers are not implemented. Although all farmers recognize the difficulties for securing advantaged selling channels and favorable selling prices of their products, no one can figure out the certain images or ideas of solutions for the problems. Not a few numbers of farmers still hold to a way of thinking that expects someone to purchase all products at an appropriate price as was experienced during the Soviet era. As a result of this rigid mind, general farmers have little awareness of agricultural marketing.

b. Middlemen

Middlemen play a significant role in the distribution of farm products, since most farmers are selling their products to them. Generally, farmers regard the middlemen's work as extortionate profit-making as indicated by the farmers' criticism of them. However, many farmers are also recognizing that selling their products to middlemen is more rational than selling the products by themselves at the market according to the last analysis. While middlemen vary from permanent workers to side business workers with farmers, most of them run a business on an individual basis. They are divided into different hierarchies, and the trading between them is commonly practiced. The middlemen can be classified into the following types, but some of them are performing multi-tasks.

- Purchasers of farm products from farmers, and sell them to middlemen from Yerevan and other regions
- Purchasers of farm products from farmers or small-scale middlemen, and sell them to retailers or middlemen from other regions at Yerevan markets or local markets in consuming areas
- Buyers of farm products at Yerevan markets, and sell them to retailers at local markets in consuming areas
- Wholesalers and/or agents of processing companies.

c. Wholesalers/Traders

Wholesalers and traders are not so small-scale as middlemen, but most of them run their businesses under private or family management. Generally, they purchase farm products from farmers through specified middlemen, and sell them to retailers and supermarkets in the same area, to middlemen from other regions and to exporters. Some wholesalers also work as traders, and they are exporting or importing seasonally advantageous fruits and vegetables. However, importation of some crops such as banana and pineapple are monopolized by the government control policy. In Armenia, there is only one company to trade vegetables and fruits on a certain large scale, so other traders are remaining at a private enterprise level.

d. Market

There are public markets in Yerevan and other regional cities. It is estimated that a substantial percentage of marketed vegetables and fruits are transacted at Yerevan markets. The reason for this assumption is that about one third of the national population is densely concentrated in Yerevan city and the main producing areas of vegetables and fruits are located next to the city. There are two public markets in Yerevan city (excluding other free markets), and shops of wholesalers which as mentioned above are located in and around the markets. The Malatia market is the biggest market in the city, and the prices of vegetables and fruits in the country are basically based on the Malatia market prices. Many middlemen who are dealing farm products in the Malatia market tend to insist that they are just farmers and they only sell their own crops.

2) Processing of agricultural products

During the Soviet era, agricultural processing industries had been well developed in Armenia due to the high demand for brandy, wine and canned fruits and vegetables from other republics. However, the country had lost those dominant markets since its independence in 1991, and numerous processing factories had been forced to close their operation because of devastating impacts of the markets lost. As a result of those transfigurations, agricultural processing had only been carried by small scale cottage industries and home manufacturing.

Since 1998, the country has actively utilized overseas assistance (WB, IFAD, USDA, USAID, etc.) to rebuild agricultural processing industries. Consequently, as of 2010, 30 canning factories, 40 wineries, 250 dairy factories, 70 meat processing factories and 4 tobacco factories are in operation across the country (Agricultural and Food Processing in Armenia, Samvel Avetisyan, USDA & CARD, 2010). Appendix C-26 shows leading processing companies of agricultural products in the country.

As a result of the above-mentioned promotion policies, the total purchased volume of vegetables, fruits and grapes by agro-processing industries had increased since 1998. But the increase has been stagnating from around the late 2000s (See Appendix C-27). Appendix C-28 illustrates to what extent Armenia's main agricultural processing industries, i.e. in vegetables, fruits and grapes, have rehabilitated as compared with the data collected before independence. According to the Appendix's table, the volumes of agricultural processing products are still well below the recorded volumes before independence, with the exception of brandy. This indicates that the rehabilitation of Armenian agricultural processing industries is still only at the halfway mark despite vigorous supportive policies of the government. In addition, production volumes since 2005 have plateaued in conformity with the volumes of vegetables, fruits and grapes purchased by processing enterprises, except for brandy production (See Appendix C-27). The reason for this stagnation is due less to material shortages and more to the failure of the agricultural products' market penetration. The agro-processing industries are needed to develop the market not only by recovering the shrunken former Soviet Union (current CIS countries) market but also by developing new markets, including domestic markets.

3) Farm gate price

Appendix C-29 shows farm gate prices of major agricultural products which were collected from farmers in the Project area. All crops indicate the lowest prices during the harvesting season and the highest prices during off-harvest season (January to March) in the winter. These price fluctuations are the uncertain factors against a stable farm management, though they are factors to bring an opportunity for a surging in agricultural profit. In fact, greenhouse cultivation and plastic tunnel cultivation are the common farming technologies for vegetables in the Project area, and some fruit farmers (such as apple growers) are preserving their crops in the low-temperature storage to adjust the shipment timing to generate their profits. As just described, some farmers in the area are trying to maximize their profits by devising ingenious ways.

While many farmers claim that the low crop prices especially in vegetables have resulted in a significantly serious situation in recent years, the situation mainly occurs during the peak harvesting season. According to a middleman in Yerevan, as the market price falls remarkably during the harvesting season of the open field vegetables (July to August) due to excess production, the middleman has not dealt with vegetables recently because he cannot ensure profit from the business. In the meantime, he can make a certain profit from the business of vegetables which are grown by forcing culture in greenhouse. It seems that farmers growing the forcing vegetables are in the same situation.

2-3-12 Profit by Crops

Profit of main crops per hectare, shown in Table 2-3.12, is calculated based on the data of the main crops' yield and production cost, which was collected from the Ministry of Agriculture, and the farm gate prices listed in Appendix C-29. The data of wheat and barley are based on Aragatsotn Marz's data, and the data of vegetables and fruits are based on Armavir Marz's data. Regarding the data about alfalfa, as no information was provided by the Ministry of Agriculture, it was calculated based on the results of interviews conducted by the JICA study team.

Table 2-3.12 Profit by Crops (ha)

Crop	Yield ton/ha	Price ADM/kg	Gross sales ADM/ha/year	Production cost ADM/ha/year	Net profit ADM/ha/year
Wheat	3.5	150	525,000	428,480	96,520
Barley	2.6	180	468,000	365,100	102,900
Tomato	46.8	80	3,744,000	1,735,000	2,009,000
Cucumber	27.6	150	4,140,000	1,363,000	2,777,000
Eggplant	42.0	100	4,200,000	1,575,000	2,625,000
Bell pepper	28.0	150	4,200,000	1,555,000	2,645,000
Cabbage	44.7	100	4,470,000	1,345,000	3,125,000
Onion	25.7	150	3,855,000	1,703,000	2,152,000
Watermelon	34.0	100	3,400,000	1,090,000	2,310,000
Potato	31.7	100	3,170,000	1,907,000	1,263,000
Alfalfa (1st year)	20.0	35	700,000	781,528	-81,528
Alfalfa (after 2nd year)	30.0	35	1,050,000	556,000	494,000
Alfalfa (7-years cropping)					411,782
Grape (adult tree)	14.5	150	2,175,000	1,661,000	514,000
Apricot	8.7	200	1,740,000	937,000	803,000
Apple	12.1	200	2,420,000	1,469,000	951,000

Source: The JICA Study Team (base on the data from the Ministry of Agriculture, RA)

The provisional calculations shown above indicate that vegetables are the most profitable crops with fruits being the next most profitable, followed by cereals as the least profitable. Most farmers are cultivating wheat as a subsistence crop only, due to its low profitability. Table 2-3.12 reveals the background. Since vegetables prices fluctuate by season as mentioned above, higher profits than the

estimation can be expected depending on the selling time. But in contrast, it is also possible that the farmers cannot recover their production costs due to a sharp downturn in the profitability. The prices of vegetables also seem to fluctuate year by year, and it is expected that not many farmers can stably generate the expected profits every year. Those circumstances are one of the main reasons why many farmers regard agricultural marketing, especially in vegetables, as a serious issue of their farming.

2-3-13 Farmer Organizations and Water Users Association

1) Farmer organizations

As of January 2013, 3,737 producer cooperatives and 307 consumer cooperatives were registered in Armenia, but it is difficult to clarify how many of those cooperatives are still actually active at present and how many agricultural cooperatives exist out of the total cooperatives. And it is also reported that many cooperatives which were established with the assistance of aid organizations are no longer in business currently. SADS mentions that the government needs to promote establishment and development of agricultural cooperatives, and the government does actually recognize the importance of them. However the real situation is so far from the vision, and the concerned legal system about the establishment, the operation and the dissolution are still not well developed. During the field study, the JICA study team could not encounter the actual activities of farmer organizations on the field except for irrigation. In addition, some farmers show a negative attitude toward the agricultural cooperatives, due to negative experiences during the Soviet era. Briefly, it is concluded that activities of farmer organizations such as agricultural cooperatives are presently very weak in Armenia.

2) Water users association (WUA)

As explained above, only the WUA (Water Users Association) is a substantially active farmer organization. 44 WUAs (42 WUAs as of August 2014), which have a total of approximately one hundred ninety thousand members (farmers) who are established across the country as NPOs, and the WUAs are managing around one hundred and eight thousand hectares of irrigated farmlands (See Appendix C-30). Appendix C-31 shows the organizational chart of the WUA, and following list shows the WUA's major roles.

- Distribution of irrigation water to the members and monitoring of the quantities of the water
- Collection of irrigation water fees from the members and the payment to WSA (Water Supply Agency)
- Gate control on the secondary canals and management of pumping stations which are owned by the WUA
- Maintenance of the secondary canals

Basically, the balance of collected irrigation water fees from members and the payments to WSA, as shown in Table 2-3.13, will be a major part of the WUA's revenue.

Table 2-3.13 Irrigation Fees (AMD/m^3)

Irrigation type	Water from WSA to WUA	Water from WUA to Farmers
Gravity based Area	1.01	11.00
Pump based Area	11.52	11.00

Source: Collected information from WUAs

As is obvious from the table, WUAs in gravity based irrigation areas can secure approximately 10 AMD/m^3 of balance profits, but WUAs will suffer a small amount of deficit from the WSA-pump irrigation. Thus, it is difficult to generate enough revenue to cover operational costs if the WUA highly depends on pump irrigation. Moreover, it is estimated from Appendix C-30 that revenue from the irrigation fees varies from WUA to WUA because there are huge differences in the different irrigation

areas managed by WUAs. Considering those circumstances, operation and maintenance costs for irrigation canals and necessary labor costs, the government subsidizes a part of the revenue of the WUAs. Some WUAs manage the necessary irrigation water not only from main canals managed by WSAs, but also the groundwater pumped from tube-wells by WUAs themselves. The government does assist with all WUAs' operational costs for those pumps and compensates the operational costs for pumps which lift irrigation water to irrigate higher altitude areas which lie above than the main canals.

From 2009 to 2011, the "Institutional Strengthening of Water Management Entities" sub-activity program, which was supported by the Millennium Challenge of USA, was implemented in order to support WUAs across the country. The management ability of each WUA was comprehensively improved by this program. The four main components of the program are listed below.

- A WUA Needs Assessment, which will assist in the development and implementation of a WUA Management Improvement Plan
- Software focusing on budgeting, accounting and GIS, as well as training on how to integrate the software packages to achieve maximum effectiveness
- New office equipment and furniture
- Heavy machinery to assist in managing, maintaining, and operating the WUA's irrigation systems

2-3-14 Agricultural Research, Education and Extension Organizations

1) Institution of agricultural research and education

According to the Ministry of Agriculture, there are three agricultural research institutions under the Ministry (See Table 2-3.14).

Table 2-3.14 Research Institutions under the Ministry of Agriculture

Name of Institution	Location	Main Research Activity/Crops
The Scientific Centre for Agriculture	Ejmiatsin, Amarvir Marz	Growing of wheat, barley and leguminous crops
The Scientific Centre of Vegetables and Industrial crops	Darakert, Ararat Marz	Selection of varieties and seed production (solanaceous, cucurbitaceae and cabbage crops)
Experimental Centre for Technical Crops		Selection of varieties and seed production (soya, tobacco, linseed and sugar beet)

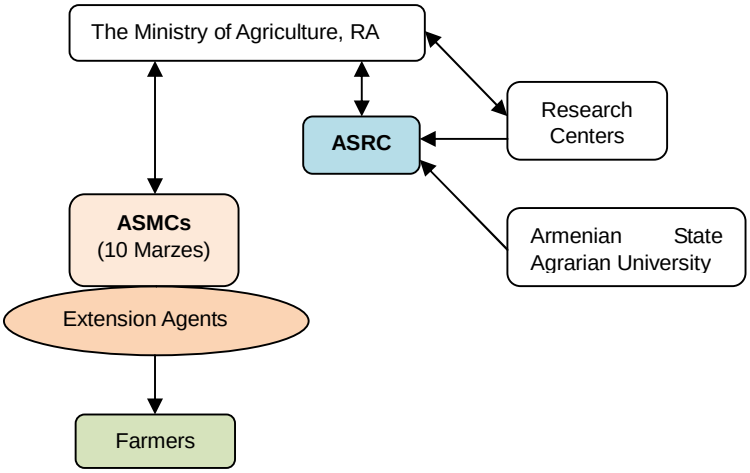
Source: The Ministry of Agriculture, RA

According to "Agricultural and Food Processing in Armenia (USDA & CARD)" written by Samvel Avetisyan in 2010, there are the "Research Center for Soil Science", the "Research Center for Horticulture, Viticulture and Winemaking", the "Research Center for Livestock Management and Veterinary" and the "Research Center for Agri-Bio Technology" in addition to the research institutions shown in the table above. However, there is no certain information about these institutions to indicate whether or not they still exist at present. As of 2010, the number of agricultural researchers in Armenia was 249, and only 25 of them hold a doctoral degree (122 are doctoral candidates). Thus, an increased number of agricultural researchers must be one of the critical challenges of Armenian agricultural development. Dealing with this circumstance, the government is aggressively promoting research cooperation programs with international agricultural research institutions such as CGIAR, ICARDA, CIMMYT, IPGRI, ISNAR and CIP as well as institutions in other countries.

In addition, the government also promotes to foster domestic agricultural researchers and experts. The Ministry of Agriculture manages the Armenian State Agrarian University, which is the only agricultural university in the country, and 10 State agricultural colleges which are located in 7 Marzes across the country. The State agricultural colleges aim to develop human resources to work as a bridge between research institutions and the actual field. Appendix C-32 shows a list of the State agricultural colleges.

2) Institutions of agricultural extension

Regarding agricultural extension, the ASRC (Agricultural Support Republic Centre) is placed at the central level and one ASMC (Agricultural Support Marz Centre) is established in each Marz at the regional level. The ASRC and ASMCs are different institutions, and there is no official hierarchical relation between them, but the ASRC plays a role of commander for agricultural extension programs in the country (See Figure 2-3.5). ASMCs play a role of agricultural extension activities to individual farmers in respective Marzes, and 130 agricultural extension agents are allocated to ASMCs in the country. (The total number of ASMC staff members is 213, including the agricultural extension agents.) The total number of agricultural extension agents, who should work for all Armenian farmers, is too small to cover all communities, which number 914 in the country. It is, therefore, difficult to implement detailed and elaborate agricultural extension activities without increasing the number of extension agents.



Source: The Ministry of Agriculture, RA

Figure 2-3.5 Agricultural Extension System in Armenia

Appendix C-33 indicates a list of agricultural consultancy services provided by ASMCs/ASRC in 2013. The agricultural extension programs are not adequate for general farmers even though the agencies provide such services. Table 2-3.15 shows the results of a questionnaire-based survey conducted with farmers by the JICA study team. According to the results, most of the farmers recognized that they've never had any opportunities of agricultural extension or supporting services. One of the reasons why farmers replied with those answers is that many farmers do not understand the contents of agricultural extension services (agricultural technical consultancy services). During the Soviet era, farm operations were prescribed by agronomists who are allocated in Kolkhoz and Sovkhoz, and there were no agricultural assistance services for individual farmers. Therefore, some farmers misunderstand that an agricultural extension service is assistance from the government to provide some materials or goods to farmers.

Table 2-3.15 Agricultural Consultancy Services Provided by ASMC/ASRC in 2013

Service	Number of Farmers	
	Yes	No
Crop production	2	18
Vegetable production	1	19
Fruits/grape production	0	20
Animal husbandry	1	19
Food processing	0	20
Agricultural credit	5	15

Source: The JICA Study Team (based on the Farm-household Survey)

2-3-15 Agricultural Finance

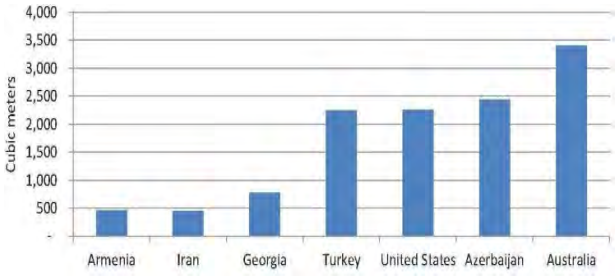
Since April 2011, the government has been implementing an agricultural finance supporting program which compensates the interest rate of agricultural credit. The subsidized agricultural credit is provided through three private banks, i.e. ACBA Credit Agricole Bank, Ardshininvest Bank and Converse Bank. The compensation rate for the interest rate by the government is 4% (ordinary interest rate in 2011 was 14 %), and more favorable rates (6%) of government compensation are implemented

for about 200 villages in the poverty-stricken areas. The payback period of the credit is more than 1 year (depending on the loan condition), and the payments are to begin after 6 months of the borrowing. Appendix C-34 describes the total amount of the agricultural credit provided by the three private banks since 2000. According to the table, the loan amounts are hugely increasing since 2011 when the governmental supporting program started. The amount of agricultural credit without the government assistance also indicates a healthy growth. The total amount of agricultural credit from private financial agencies excluding the above three banks was about forty billion ADM in 2013, and the amount as of June 2014 has already exceeded the total amount in the last year.

2-4 Irrigation Sector

2-4-1 Water Resources/Irrigation Policies

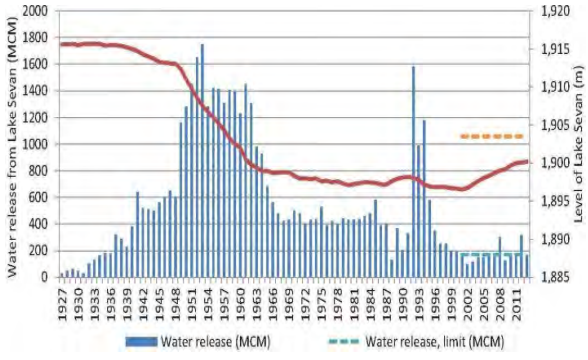
Though a large discharge quantity by thawing in the early spring can be expected in streams in Armenia, river discharges become scanty in June/July and later. This is why the construction of reservoirs is a prerequisite in order to make stable use of water resources. In Armenia, 87 medium to small scaled reservoirs have so far been constructed during the period including the one under Soviet regime. As one of them, the Marmarik reservoir (storage capacity: 24MCM) was constructed in 2012 at the upstream of Hrazdan River, and now planning of constructing reservoirs are still on-going. Yet, despite such plans, the storage capacity of reservoirs/water storage facilities per capita in Armenia is smaller as compared to that in Turkey, one of the neighboring countries (refer to Figure 2-4.1), only about 20% of that in the Turkish territory, lying on the opposite side of Ararat Plain. Accordingly, given limited land resources and meteorological conditions, it is imperative for Armenia to secure water resources efficiently and appropriately.



Source: World Bank (2014),Towards Integrated Water Resources Management : Revisited

Figure 2-4.1 Capacity of Water Storage Capacity per Capita in Armenia and Neighbor Countries

In Armenia, reservoir construction has been planned, but the conservation of Lake Sevan, with the largest water storage capacity in the country, is no less important. Armenia has diverted watersheds by constructing the Arpa-Sevan and Vorotan-Arpa tunnels as conservation measures of Lake Sevan, thus keeping relevant use of the lake, learning from lessons of dropping water levels in this lake that occurred in the past. Furthermore, in 2001, Armenia launched an environmental improvement strategy for Lake Sevan with the target of elevating its water level by 6m (up to 1,903.5m) by 2030. Additionally, the country has not only determined the upper limit of annual releasing (intake) water volume from Lake Sevan to an irrigation network at 170MCM, but it also decided to operate hydropower stations located along the Hrazdan River only during the period of practicing irrigation, thereby addressing the recovery of the lake-water level (refer to Figure 2-4.2).



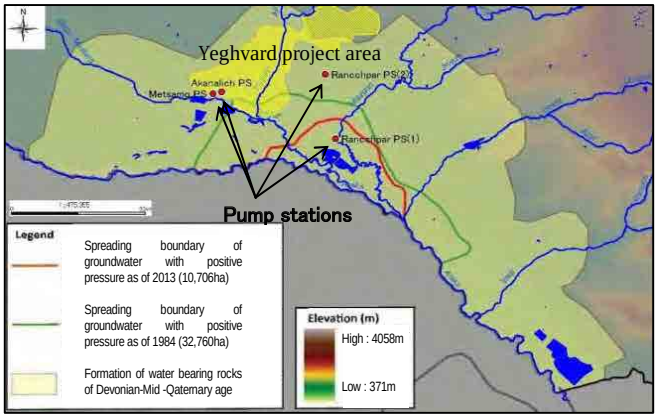
Source: World Bank (2014),Towards Integrated Water Resources Management : Revisited

Figure 2-4.2 Change in Water Level in Lake Sevan

As mentioned above, the Government of Armenia has taken the initiative to conserve Lake Sevan in

such an integrated manner as watershed diversion by tunnels and practice of limiting intakes from the lake, in contrast with the current state in neighboring countries where environmental problems have taken place including descending water levels in lakes. As a result, the water level in Lake Sevan tends to have been increasing since 2003, with visible fruit of its strategic effort for recovery. Such a desirable concept will continuously be handed down to younger generations. At the same time, the Government of Armenia not only constructs new reservoirs and conserves natural water resources including Lake Sevan, but also considers watershed management as an important strategy to relevantly utilize its limited water resources. In the future, it will envisage efficient use of water resources by adequately managing watersheds of individual streams.

With regards to irrigation policies, the government aggressively deploys the policy of converting irrigation methods from pump-dependent to gravity. There lies a background behind this strategy in which in addition to a concept of "getting rid of hitherto energy intensive agriculture", an issue of lowering groundwater level intervenes. In particular, the groundwater level has been drawing down in the Ararat Plain, where there is, as reported, growing difficulty in lifting groundwater by some pumps. Figure 2-4.3 shows the distributed range of artesian water map provided by the WB, on which the sites of facilities related to the Yeghvard irrigation project are superposed. The green line in this Figure indicates the spreading area of artesian groundwater as of 1984, while the red line shows the area as of 2013. Also, the yellow part indicates the beneficiary of the Yeghvard project (12,200ha) and the red circles show the location of the pumping stations related to the Yeghvard project. The prevailing state of groundwater drawdown around the sites of pumping stations related to this project is clearly marked in Figure 2-4.3. As such, irrigation polices have been initiated, intending to get the country itself free from agriculture which is heavily dependent on energy, while at the same time focusing on a shift from dependence on groundwater to effective use of surface water.



Source: Base Map: World Bank (2014). Towards Integrated Water Resources Management (Revised)

Figure 2-4.3 State of Groundwater Drawdown in Ararat Plain

As stated above, discharge levels in Armenian streams greatly vary with annual seasons. It follows that making an effective use of river water, the discharge of which is increased to its maximum in early spring when snow melts, will lead to sustainable development, in particular in such streams with large watershed area such as the Hrazdan River. This concept of development, instead of the newly damming up of streams, gives only a minor impact to the environment. As shown in Figure 2-4.4, stream water is to be converted into the reservoir utilizing the existing canal during the period that river discharge outweighs water demand, with the limit set at the cross-sectional area of the existing canal. In general, in the case/period that river discharge is below water demand, other water sources,

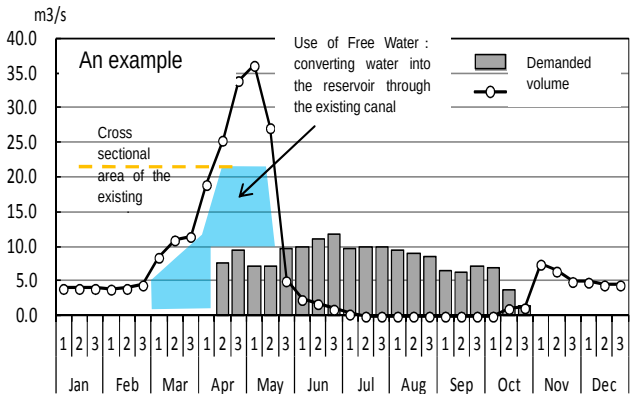


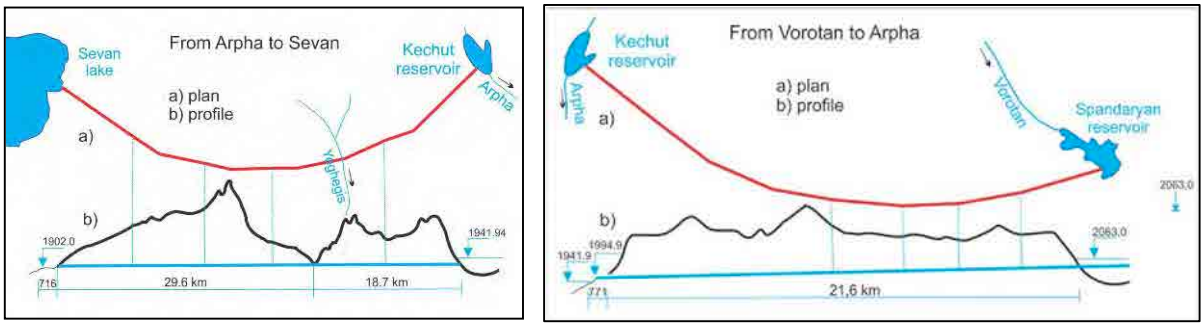
Figure 2-4.4 An Image of Utilizing Free Water

including Lake Sevan and pump stations have so far been utilized, whereas this concept has a benefit of enabling irrigation free from depending on other water sources and also during the water depleting period in streams by storing free water inside the reservoir.

2-4-2 Water Resources/Land Resources

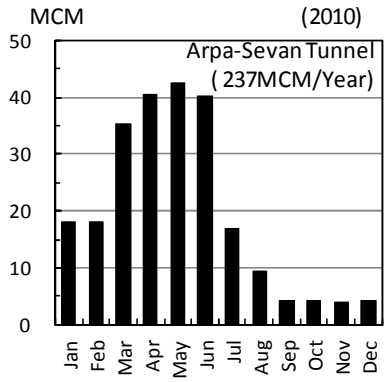
Concerning Lake Sevan, laws and regulations have been instituted on its environmental conservation, rehabilitation, restoration, natural resources development, use of resources, etc. In this regard, an Expert Commission has also been established consisting of 9 committee members under the National Academy of Science. Lake Sevan has a surface area of around 1,414km^2 and had a water storage volume of 58,000 m^3 before 1930, but its water level has sharply dropped since the 1930s, owing to heavy water use for irrigation and domestic/potable water. By 1972, its water level had been lowered by as much as 19m, and the water surface area had been enormously reduced. Currently, it has about 1,200km^2 of water surface area and a storage volume of 34,000 million m^3.

Lake Sevan has been connected to the Capital Yerevan and the Hrazdan River that flows into the Ararat Plain, and lake water has been utilized for irrigation and hydro-power generation along/through this river. Aside from this, as a recovery measure of the lake's water level, the Arpa-Sevan water-tunnel, 48km in total length and 250MCM/year of discharge volume, was constructed during the period 1963-1982, connecting the Arpa River with Lake Sevan. Also, the Arpa-Vortan water-tunnel has been completed, connecting the Arpa River with the Vortan River following a similar concept to the former, with a dimension of 22km of total length and 165MCM/year of discharge capacity. In this context, the Arpa-Vortan tunnel is now under rehabilitation and is not used. The monthly discharge record (2010) of an Arpa-Sevan tunnel is shown in Figure 2-4.6. (see Appendix D-1)



Source: ATLAS (2007)

Figure 2-4.5 Arpa-Sevan Tunnel and Arpa-Vortan Tunnel



Month (2010)	Discharge (MCM)	Month (2010)	Discharge (MCM)
Jan	18.0	Jul	16.9
Feb	17.9	Aug	9.5
Mar	35.4	Sep	4.1
Apr	40.4	Oct	4.2
May	42.6	Nov	3.9
Jun	40.2	Dec	4.1
			Total 237.2

Source: Hydro-meteorological Service of the Ministry of Emergency Situations

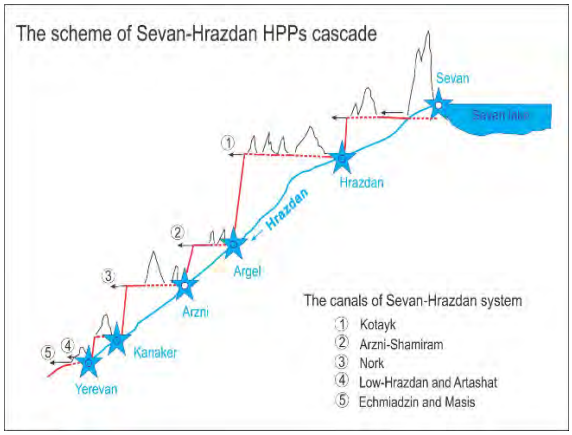
Figure 2-4.6 Monthly Discharge of Arpa-Sevan Tunnel (2010)

The Ararat Plain constitutes an economically active area where agriculture and aqua-culture are greatest developed in Armenia. In this plain, favorable quality artesian groundwater extends. This groundwater has been utilized not only for agriculture and aqua-culture but also for potable water. However, since 2006, because a host of aqua-culture enterprises has emerged which began to utilize groundwater, a drawdown of the groundwater level has lately been conspicuous inside the Ararat Plain. Concerning this, comparing the depth of the artesian groundwater level in 1983 to that in 2013, the decline was said to be as much as 6-9m (reported by the WB). Currently, a pronounced drawdown of the groundwater level in the Ararat Plain has caused a conflict of interest/dispute among users, including irrigation, potable water, industries and cooling water for atomic energy power generation.

2-4-3 Allocation of Water Use

The Water Supply Aency (WSA) has executed water distribution in Armenia. WSA is the responsible agency for water supply in Armenia, consisting of two organizations, namely, Sevan-Hrazdan CJSC and Akhuryan-Araks CJSC. Both of them belong to State Committee of Water Economy.

Water flowing in the Hrazdan River is composed of water derived from its own watershed area and that conveyed from Lake Sevan. Objectives of utilizing water in Lake Sevan are irrigation and hydro-power generation. Along the Hrazdan River, 6 hydropower stations have been operated making use of the topographic features of a mountainous region. From the high elevation of Lake Sevan toward the Ararat Plain, hydropower stations are operated in a cascading manner (see Figure 2-4.7). A Russian private enterprise runs and manages these stations.



Source: ATLAS(2007)

Figure 2-4.7 Cascade Type Water Use in Sevan-Hrazdan Hydropower Generation

WSA carries out allocation of irrigation water. WUA, the user of irrigation water, purchases it from WSA. WUA, prior to water use, issues a request of allocating water volume equivalent to an average volume necessary to irrigate a decade to its beneficiary. Based on this request by WUA, WSA determines the volume of water supply thereto in consideration with water use in other sectors and the available volume of water resources.

In Armenia, water use for irrigation has a higher priority than that for hydropower generation. The hydropower sector can utilize water during the period of April-October, season of irrigation, but it does not function at all during the non-irrigated period. In this context, cities located adjacent to the Hrazdan River, including the Capital Yerevan, utilize groundwater for domestic water uses. Thus, the water in the Hrazdan River has been used only for irrigation and hydropower generation.

2-5 Geological/Hydrogeological Conditions

2-5-1 National Geology and Hydrogeology

Two rows of the Caucasus Mountain Ranges, the greater and the lesser, bridge the Black Sea and the Caspian Sea. In the south of the Ranges, the Armenian Highland extends widely from the Aegean Sea in the west to the Iranian Plateau in its southeast, with an average height from 910 to 2,100m msl. The Republic of Armenia is located in almost the central part of the Armenian Highland.

It is said, in the middle of the Miocene epoch (around 13 million years ago), the small Arabian Plate

collided with the huge Eurasian Plate in the NNE direction. Such large scale geological movement with subsequent heavy volcanic activity in this area formed the Caucasus Mountain Ranges and up-heaved the Armenian Highland. Also, such geological movement destined Armenia as one of the highly quake-prone countries, like Japan.

The geological framework of Armenia consists of a Pre-Cambrian Basement, Paleozoic and Mesozoic Sediments, and Metamorphic distributing only in the northeast and southwest hedges of the country, and Cenozoic volcanic formations widely covering the central to eastern part of the territory. A schematic geological map of Armenia is shown as Figure 2-5.1.

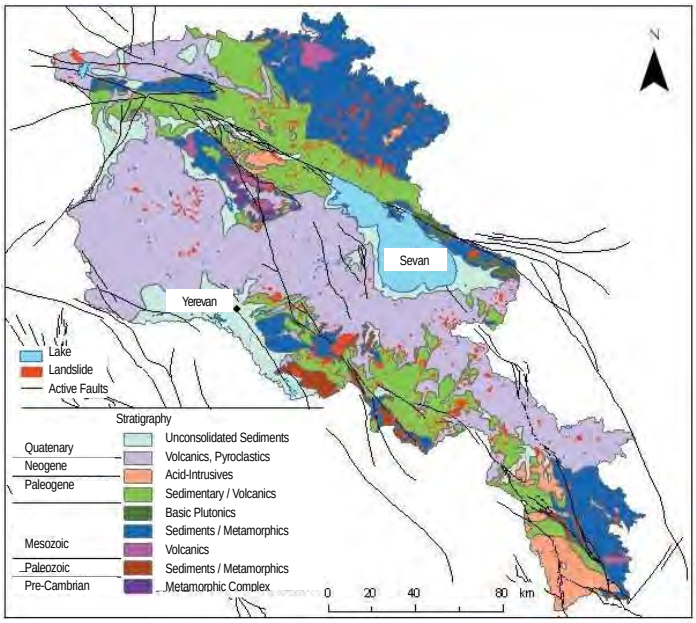


Figure 2-5.1 Schematic Geological Map of Armenia

As shown in the Figure, the area near around the Project site is also widely covered by Cenozoic volcanic complex and partially by alluvial deposits.

2-5-2 Groundwater Condition in Ararat Plain and Yeghvard Area

In spite of being a less rainy country of from 250 mm (in the Lower Araks River Valley) to 800 mm (mountain area) of yearly rainfall, the hydro-geological condition in the plain areas, along with large rivers and lake, are rather favorable. The largest plain of the Ararat River Plain has a groundwater aquifer with a highly artesian condition, as around +5, 6m, and +15m sometime of piezometric head. Most of the groundwater wells yield more than several hundred, sometime around 1,000 lit/sec of groundwater. However, these artesian condition and water yields are said to be decreasing more and more recently. Groundwater yields near around Lake Sevan are also high, such as 50 to 100 lit/sec.

Heavily contrasted with these plain areas, the Yeghvard area, the Project site, has quite a poor hydro-geological condition, such as small rainfall (less than 300 mm/year), no constant surface flow, heavily permeable ground cover, and a very deep groundwater table. No groundwater well is located near around the site. Only two borings among many core borings drilled by the ex-USSR for the Yeghvard reservoir in the D/D Study detected groundwater tables at the depths of 91.5m and 120.5m, which is quite deep, but the water quality was fresh.

2-5-3 Active Faults and Earthquakes

Figure 2-5.2 shows a location map of active faults in Armenia, together with historical earthquake epicenters, provided by the Institute of Geological Science of Armenia. Because of these large active faults, Armenia has suffered from earthquakes repeatedly, the same as Japan. As shown in the figure, the Garni Fault is the nearest active fault from the reservoir site, but it is far enough at about 20 km.

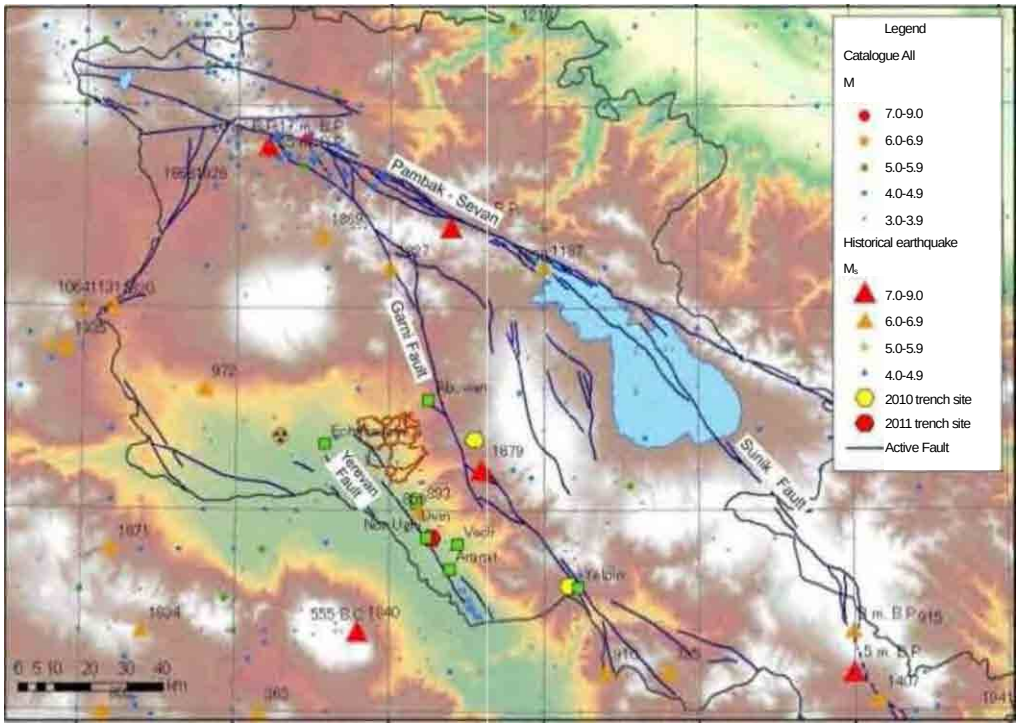


Figure 2-5.2 Active Faults in Armenia

In the reservoir area also, there are several small faults. Typically they are observed in the volcanic sands layers, included in "Delluvial-Proluvial-Lacustrine Sediments (lap-ap-lap QI-II)" of the early to middle Quaternary, because they show a very clear bedding structure. The volcanic (or pumice) sands are currently used for construction materials and excavated everywhere. Near the dam site also, the sands are excavating at just beside the main asphalt road passing south of the dam site, where the layers were exposed clearly on the quarry site (see Figure 2-5.3). As shown in the photo, some faults with sharp and straight fault faces are observed. However, the gaps of these are rather small, from several tens of centimeters to less than 100cm. These faults did not cut the volcanic rock complex overlain and there is no deformation on the ground surface caused by activities of faults, which is a formation of the late Pleistocene age. That means small faults distributing in and around the reservoir area can be defined as non-active faults.

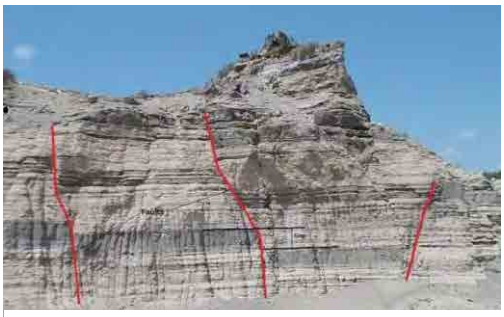


Figure 2-5.3 Faults in Sedimentary Structures

2-5-4 Landslide condition

Geo-tectonics of Armenia (Plate movement and active faults) causes heavy earthquakes frequently. The surface geology of the northwest portion of the country is rather soft sedimentary rocks or metamorphic rocks of Mesozoic to Tertiary. The large portions from the middle to the south of the territory are covered by volcanogenic formations which include relatively fragile scoria and/or pumices layers. Thus, more than two thirds of the country's land has conditions apt to cause landslides.

In accordance with "the Study on landslide Management of Armenia" undertaken by JICA in 2004, a total of 2,504 landslides are identified in Armenia, mainly in the north, middle-west, and south of the country, where sedimentary and volcanic rocks of Mesozoic, volcanogenic formations of Neogene to Quaternary, and sedimentary and volcanic rocks of Paleogene are mainly underlying respectively (refer to Figure 2-5.1 Schematic Geological Map of Armenia).

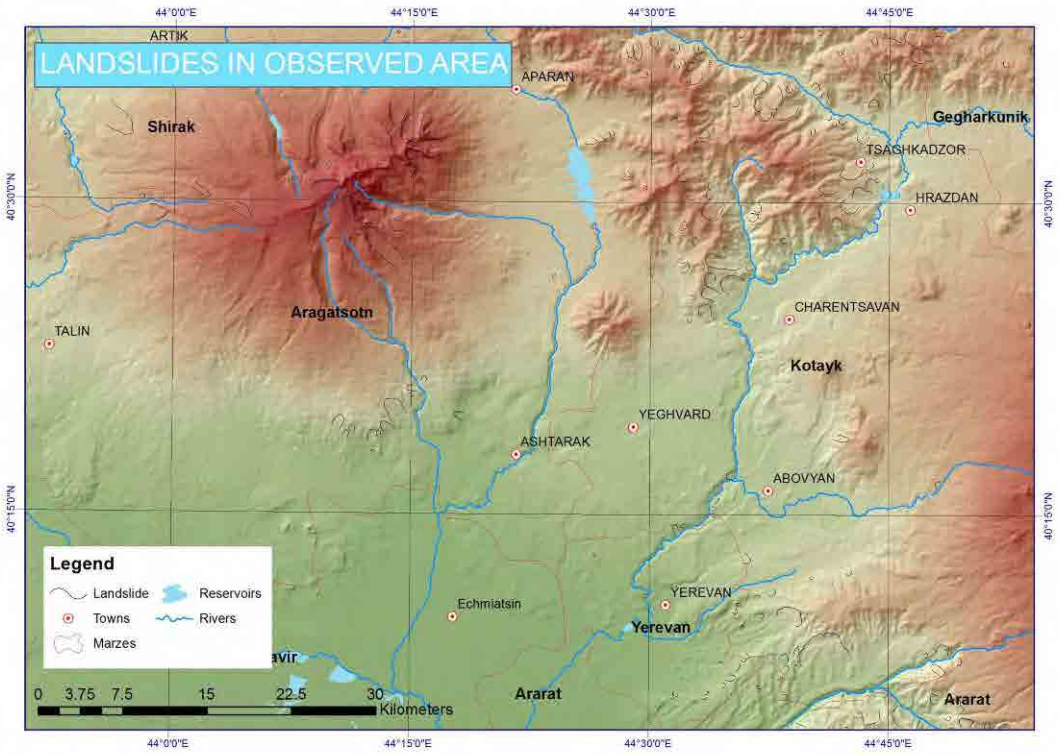


Figure 2-5.4 Location Map of Landslides near Yeghvard

On the other hand, the area near around the Yeghvard reservoir is also underlain mainly by Quaternary volcanogenic formations. However, the slopes of the basin are very gentle (maximum slope inclination is less than 15 degrees), and there is no surface water or groundwater, which are the most severe triggers of landslides. Figure 2-5.4 shows a location map of landslides near the Yeghvard, extracted from the report of the aforementioned JICA Project. As shown in the figure, there is no landslide near around the Yeghvard area.

2-6 Law/Standards for Reservoir Design

2-6-1 Reservoir Design Standard

1) Reservoir classification

A reservoir is classified according to its height and storage volume, and necessary analysis with the required capacity (e.g. safety factor) determined by class. The criteria of classification are prescribed in “Building codes 33-01-2003” (see Table 2-6.1). Classification is evaluated by item and the highest class among them is selected. According to the criteria, the Yeghvard reservoir is classified as class III.

On the other hand, there are other criteria for classification from the viewpoint of damage in case some accidents happen on the reservoir. The criteria include such things as number of people who may be affected, number of people whose living conditions may be disrupted and housing density within area damaged by accidents. The way to calculate these numbers and actual situation at the downstream side of the Yeghvard Reservoir will be confirmed at the F/S stage and if necessary the classification of the reservoir will be changed.

Table 2-6.1 Criteria for Reservoir Classification (created based on Building Codes 33-01-2003)

		Class I	Class II	Class III	Class IV
Height H (m)	Rock ground foundation	More than 80	From 50 to 80	From 20 to 50	Less than 20
	Sandy and Coarse ground foundation	More than 65	From 35 to 65	From 15 to 35	Less than 15
	Saturated and clay foundation	More than 50	From 25 to 50	From 15 to 25	Less than 15
Reservoir storage capacity V (MCM)		More than 1,000	From 300 to 1,000	From 10 to 300	10 and less

*Yeghvard reservoir: Height(H) =about 33m, Storage capacity (V) =90MCM

2) Reservoir design standard

The present standard for reservoir design is "Construction codes 2.06.05-84*." This standard was issued in 1984 and revised in 1990 by the Soviet Union (a mark * means revised version). In this standard, reservoirs are categorized into four (4) types by its structure, Earth fill dam, Hydraulic fill dam, Earth-and-rock fill dam and Loose-rock-dam, and notice point for design and construction for each type are described. Additionally, general contents of seismic analysis and construction methods are described in the standard as well; however, this standard requires one to refer to other standards for the detail of those matters.

This standard was established by the Soviet Union, targeting reservoirs located in a very cold area. Since the temperature of the Yeghvard reservoir site in the winter season is about minus 20 deg C, some consideration for design and construction of a reservoir located in a very cold area described in the standard will be adopted if necessary.

On the other hand, at Dam No.1 a concrete intake structure remains. According to its arrangement, it is assumed that this intake structure was arranged to pass through the dam body. This kind of structure is not permitted in the Japanese standard because there will be a gap between the dam body (soil structure) and intake facility (concrete structure) when an earthquake happens and the water storage function of the reservoir will be impaired.

Considering these situations, the reservoir design at the F/S stage is required not to just follow the design standard in Armenia but to adopt some concepts of the Japanese standard if necessary.

2-6-2 Seismic Analysis Standard

The methodology of reservoir stability analysis is described in the reservoir design standard "Construction Codes 2.06.05-84*." On the other hand, calculation methodology of seismic acceleration necessary for reservoir stability analysis is prescribed by "Earthquake resistant construction design codes RABC II-6.02-2006" (hereinafter referred to as seismic codes). In seismic codes, there are not only general concepts of seismic acceleration for design but also some specific descriptions about calculation procedure of seismic acceleration for "residential, public and industrial buildings and structures," "transportation related structures," and "hydrotechnical structures." Additionally, there are descriptions of seismic isolation system and restoration of structures. Nuclear power station is not the target of these seismic codes.

The following formula is prescribed in seismic codes as a formula to calculate seismic acceleration utilized for reservoir stability analysis.

$$a_{dk} = g \times A \times k_0 \times k_1 \times k_2 \times \sqrt{\sum_{i=1}^{v} \left(\beta_i \times \eta_{ki}\right)^2}$$

where:

a_{dk}: acceleration at point k

g: gravity acceleration

A: seismic impact intensity coefficient (target is 1 time / 500 years earthquake)

*for vertical force 0.7A is adopted.

k_0: soil condition coefficient

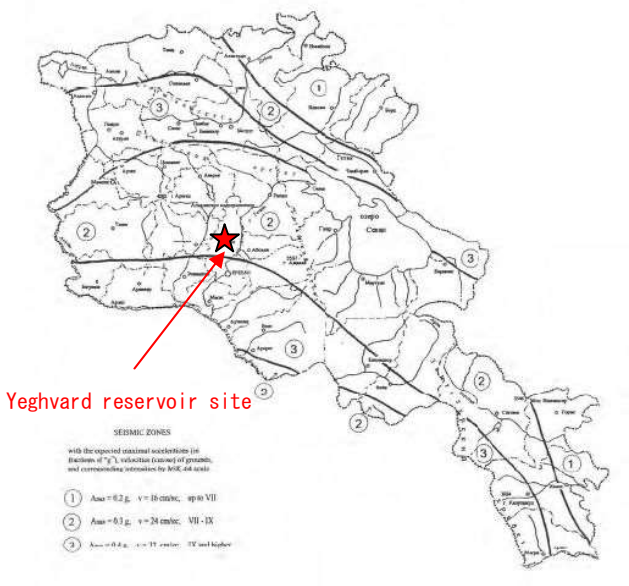
k_1: permissible damage coefficient

k_2: structures importance coefficient

β_i: dynamic coefficient corresponding to i^{th} mode of oscillations

η_{ki}: dimensionless coefficient at point k depending on the ordinates of the i^{th} mode of oscillation

Among the coefficients mentioned above, the numbers of A, k_0, k_1, k_2 are prescribed in the seismic codes (see Figure 2-6.1 and Table 2-6.2 - 2-6.4. *Numbers to be adopted for the Yeghvard reservoir are highlighted with a red square). On the other hand, to calculate β_i and η_{ki}, a preliminary analysis, Eigen analysis by 2 dimension FEM model, is needed.



6 Kotayq Marz

Aghavnadzor	2	Hatis	2
Alapars	2	Hatsavan	3
Aragyugh	2	Bjni	2
Argel	2	Byureghavan	2
Aramus	2	Voghjaberd	3
Arzni	2	Greghadir	2
Arzakan	2	Geghard	3
Arinj	3	Goght	3
Artavaz	2	Jrvezh	3
Meghradzor	3	Fantan	2
Kaputan	2	Tsaghkadzor	2
Qaghsi	2	Dzoraghbyur	2
Kotayq	2	Kasakh	2
Zovk	2	Zar	2
Zovuni	2	Meghradzor	2
Lernanist	2	Solak	2
Proshian	2	Nor Geghi	2
Nor Hajn	2	Yeghvard	2

Seismic Zone	1	2	3
A	0.2 (200gal)	0.3 (300gal)	0.4 (400gal)

Figure 2-6.1 Seismic Impact Intensity Coefficient

Table 2-6.2 Soil Condition Coefficient (k_0)

Category of reservoir foundation

Soil Category	Vertical section of soil is uniform	Vertical section of soil is non-uniform	
		Share Wave propagation velocity Vs (m/sec)	Predominant period T_0 (sec)
I	Hard rocks of all types	800<Vs	T_0<=0.3sec
II	Rocks *Macro-fragmental ground not assigned to Category	500<Vs<800	0.3<T_0<=0.6sec
III	Water saturated gravelly sands of high and medium coarseness, high and medium density	150<Vs<500	0.6<T_0<=0.8sec
IV	Loose sands regardless of grain size and water content	Vs<150m	0.8sec<T_0

*Foundation category of Yeghvard reservoir is not clear at present.

k_0

Soil Category	Seismic Zones		
	1	2	3
I	0.7	0.8	0.9
II	1.0	1.0	1.0
III	1.3	1.2	1.1
IV	1.5	1.3	1.0

*Selected by foundation category and seismic zone of target site set from Figure 2-6.1.

Table 2-6.3 Permissible Damage Coefficient (k_1)

Condition	k_1
For class I water-retaining hydrotechnical structures	0.40
For other concrete and reinforced concrete hydrotechnical structures	0.35
For earth-fill structures	0.30

Table 2-6.4 Structures Importance Coefficient (k_2)

Condition	k_2
For class I water-retaining hydrotechnical structures	1.2
For other concrete and reinforced concrete hydrotechnical structures	1.0

* k_2 for Yeghvard reservoir is considered as 1.0. However k_2 to be adopted for soil structure shall be confirmed at FS stage because the description of k_2 in above table is specialized for concrete structure.

2-7 Loan Project Procedure

1) Loan project procedure

The required procedures for loan project in Armenia are 1) Feasibility Study (F/S), 2) Loan Request, 3) Loan Negotiation, 4) Loan Agreement, 5) Detailed Design and 6) Construction. At the Loan negotiation stage, an internal structure named "the Intra Governmental Discussion" mainly conducted by the Ministry of Foreign Affairs is established for the Armenian side for internal coordination such as collecting comments from related agencies in Armenia and the modification/finalization of the "Draft Loan Agreement" (detailed procedure of Loan negotiation is shown in the Figure 2-7.1).

Based on a finalized "Draft Loan Agreement," the final negotiation and singing of the agreement are done at the stage of Loan Agreement. The signed agreement is checked to ensure it is corresponding to international and domestic law by a Constitutional Court and ratified by the National Assembly. Finally, the nation's president signs on the ratified agreement (detail procedure of Loan Agreement is shown in the Figure 2-7.2).

In Armenia, there is no official procedure for the approval of project implementation. The Armenian president's signature on the agreement grants approval to go to the implementation stage, Detailed Design and Construction.

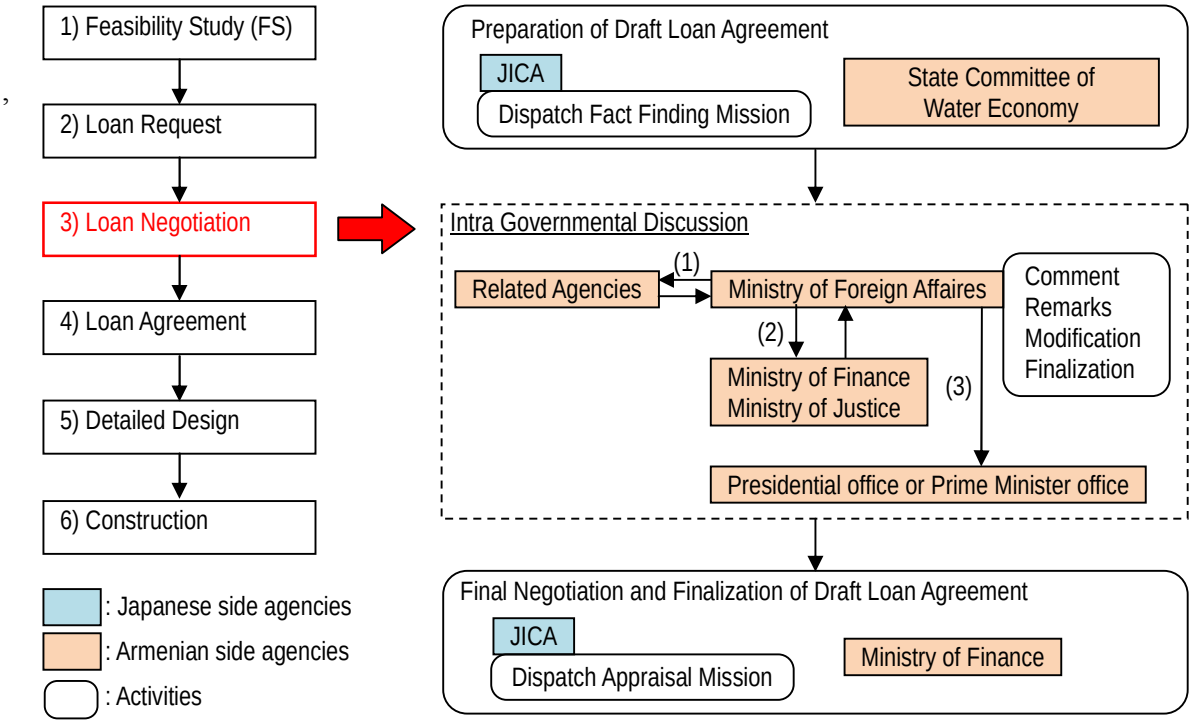


Figure 2-7.1 Detail Procedure of Loan Negotiation

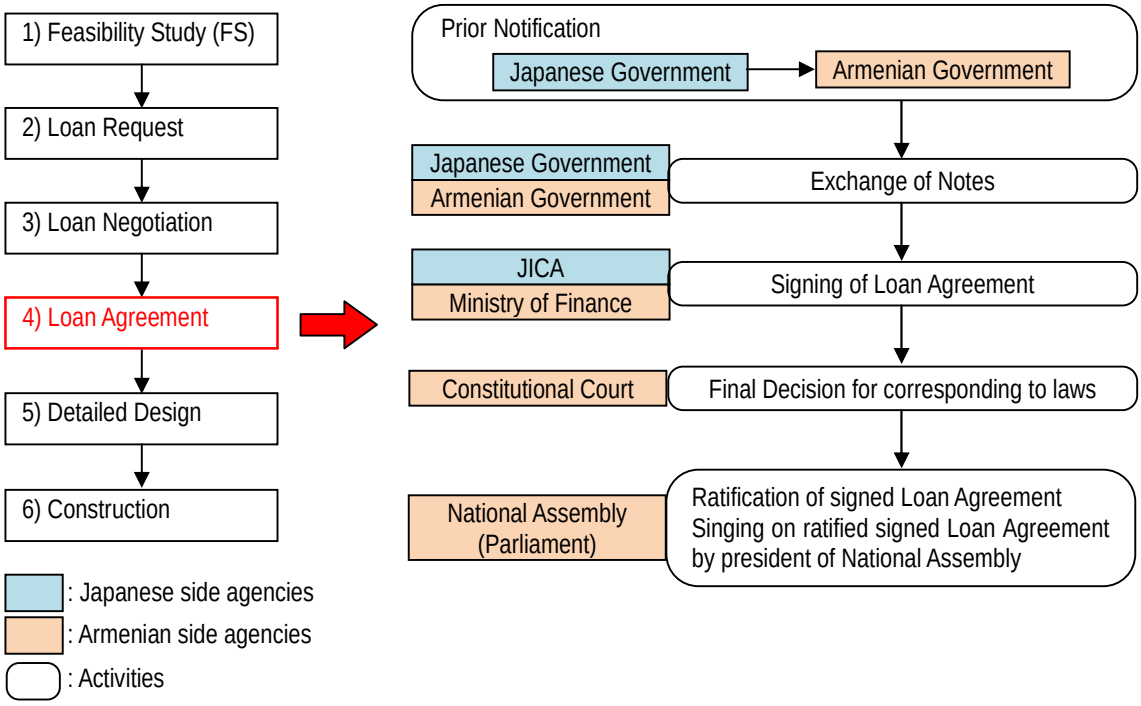


Figure 2-7.2 Detail Procedure of Loan Agreement

2) Main issues to be noticed during construction stage

The following are main issues to be noticed during construction with an outline of necessary actions.

Custom clearance (Agency having charge: Ministry of Finance)
Basically there is no tax exemption system in Armenia. There are tax laws and customs code, and target items and conditions for taxing are described in these laws/code. Based on these laws/code, both donor country and Armenian governments negotiate about target items and taxing conditions for a target project and the results of negotiation shall be described in the Loan Agreement.

Land acquisition (Agency having charge: State Committee of Cadastre)
There are civil codes for land acquisition and a law for temporal land use for construction. Negotiation with land owner is done based on the commercial price of target lands. At present there are few farmers doing agricultural activities within the planned site of the Yeghvard reservoir, however they already understand that they will stop agricultural activities and move to another place after commencement of construction.

Earth material collection (Agency having charge: Ministry of Energy and Natural Resources)
Collection of earth materials shall be carried out according to “Low on sub soil”.

Environmental reference value (Agency having charge: Ministry of Nature Protection)
There is a regulation for reference value for noise, dust, water quality and so on during construction. The target items and exact reference value with which the contractor shall comply during the construction stage shall be mentioned in the Environment Management Plan, and target items are monitored throughout the construction stage (see 2-8 Environmental and Social Impact Assessment Procedure).

2-8 Environmental and Social Impact Assessment Procedure

1) Law of environmental and social impact assessment

A law named "Law on EIA and expertise" (hereinafter referred to as EIA law) was issued on 9th August 2014. At present this law is only one law regarding EIA in Armenia. Since this EIA law was just issued, the Yeghvard, Kaps and Vedi project will be one of the first reservoir projects which EIA carries out according to this EIA law.

2) Categorization of a project

A target project is categorized as Category A, B or C according to its impacts to environment and society. As for hydraulic structure, criteria of categorization are shown in the Table 2-8.1. Since storage capacity is planned as 90MCM, the Yeghvard project is categorized as Category A.

Table 2-8.1 Criteria of Categorization for Hydraulic Structure

Category	A	B	C
Criteria	- Reservoir or artificial lake with storage capacity more than 1MCM - Sewerage treatment station targeting 50,000 and more residents	- Sewerage treatment station targeting from 5,000 to 50,000 residents	- Drying or drainage system with length 5km and more

3) Necessary assessment at each project stage

Environmental assessment is required at the F/S, Detailed Design (D/D) and Construction stage. The names of the required assessments and main activities at each project stage are shown in the Figure 2-8.1.

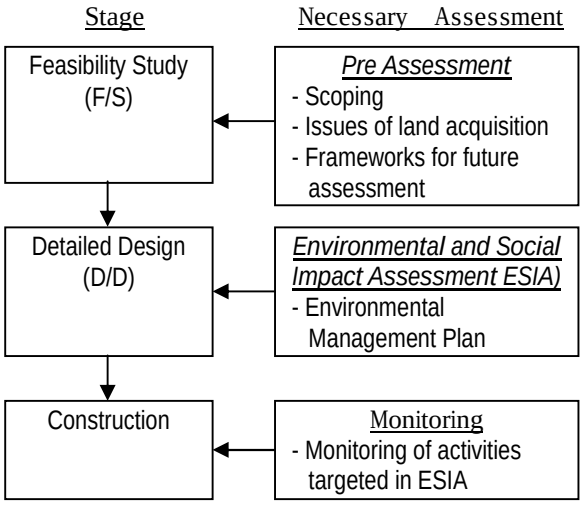


Figure 2-8.1 Required Assessment at Each Project Stage

Pre Assessment (F/S stage)
Main activities are scoping and preparation of frameworks for future assessment.

Environmental and Social Impact Assessment (ESIA) (D/D stage)
Main activities include the creation of the Environment Management Plan to be utilized for monitoring during the construction stage (see Table 2-8.2).

Monitoring (Construction stage)
Based on the Environmental Management Plan created in ESIA, target items are monitored. The responsible agencies for monitoring provide the results to PIU.

Table 2-8.2 Environment Management Plan

No.	Activity	Negative impacts by activity	Counter measures against negative Impacts	Responsible agency to execute counter measures	Responsible agency for monitoring
1	Excavation to take soil material	Deforestation	Forestation	Contractor	MNP
2					

4) Procedure of Pre-Assessment and ESIA

Procedure of Pre-Assessment and ESIA described in EIA law is shown in the Figure 2-8.2. Each assessment has 2 stages, 1) Initial stage and 2) Main stage and the procedure of both assessments is the same.

A project with Category C requires an Initial stage only but Category A or B requires both Initial and

Main stages. However EIA law has no description about the difference of required assessment for Category A and B projects.

Initial stage

Main activities are preparation and expertise of initial assessment application document. The contents of expertise are predetermination of environmental impact by project, required assessment in Main stage for a project with Category A or B, conclusion of a project with Category C and so on. The expertise is carried out during 30 business days after submitting the initial assessment application document.

Main stage

Based on the results of Initial stage's expertise, EIA is carried out. Results of EIA are arranged as a report and this report is legitimized by an authorized body. The expertise is carried out during 60 business days for Category A project and 40 business days for Category B project after submitting the report from undertaker.

The conclusion of expertise is put on the website of the authorized body during 7 business days. The conclusion of expertise losses its force if next stage of project does not start during one year after positive conclusion is given.

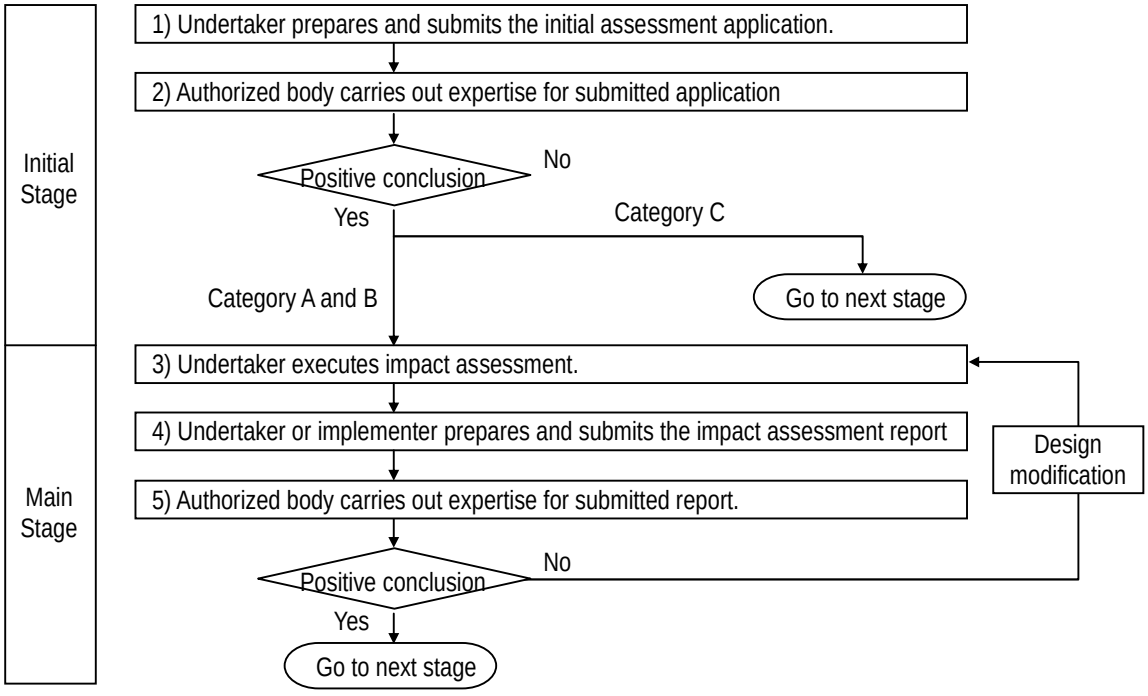


Figure 2-8.2 Procedure of Pre Assessment and ESIA

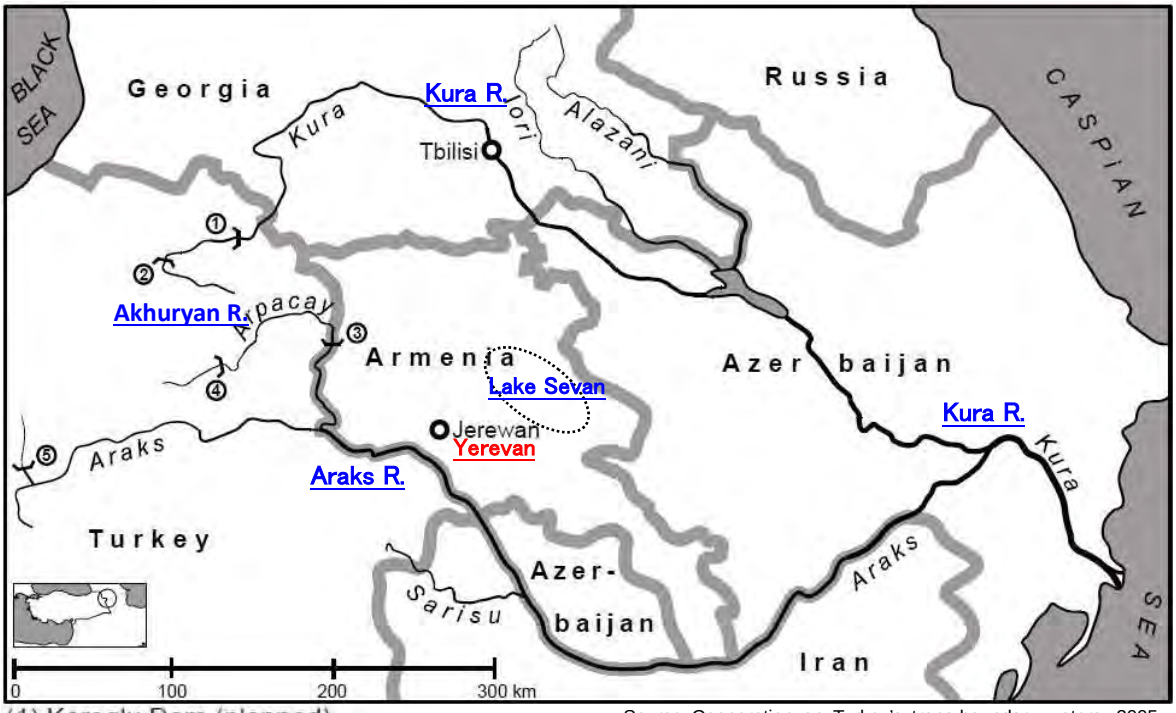
5) Contrast with JICA's guideline

In JICA's guideline, there is a description that EIA shall be implemented by the recipient country side. On the other hand, in the EIA law in Armenia, the project "Undertaker" is determined as EIA implementer and both the PIU and consultant of the donor country can be an undertaker. Since EIA has been carried out by a consultant of the donor country in Armenia, the PIU has the understanding that the Japanese consultant will implement EIA for the Yeghvard project.

The above issue is a topic to be considered again when the beginning of F/S stage.

2-9 Recent Situations of Trans-boundary Water Right, River Agreements

The River Araks, to which attention should be paid on the consideration of water right of trans-boundary rivers in this Study, stems from the Highland of Armenia, runs through the Turkish territory toward the east, and then flows down along the borders of Armenia with Iran and Azerbaijan, merging into the Kura River, finally flowing into the Caspian Sea (refer to Figure 2-9.1).



Source: Cooperation on Turkey's trans-boundary waters, 2005

(1) Koroglu Dam (planned)
(2) Besikkaya Dam (planned)
(3) Arpacay Dam **(Akhuryan Dam)**
(4) Bayburt Dam (under constructon)
(5) Demirdoven Dam

Figure 2-9.1 Trans-boundary Rivers in and around Armenia

The overall water use agreements on the River Araks, a trans-boundary river, are summerized in the Table 2-9.1:

Table 2-9.1 Past Water Use Agreements on the Trans-boundary Rivers in Armenia and Adjacent Countries

	Related countries	Agreed period	Outline
1.	Armenia under Soviet Union	January, 1927	Quantity of water intake from Araks River & Akhuryan River was agreed at 1,230 million m^3/year/country (share of water right 50:50)
2.	Turkey, Armenia under Soviet Union	January, 1927	Agreement on the survey & construction of headworks traversing Araks River. Identification on the scale of the facility & joint development by both countries (share of water intake 50:50)
3.	Turkey, Armenia under Soviet Union	October, 1973	Agreement on the joint development of a dam of Akhuryan River (share of water intake 50:50)
4.	Iran, Armenia under Soviet Union	August 1957	Share of water intake for irrigation, power generation and domestic water from Araks River and Atrak River is agreed at 50:50 & the dam is jointly developed.
5.	Republic of Georgia & Republic of Armenia under Soviet Union	November 1971	Detailed agreement on the share of water intake after constructing headworks in Debed River (a tributary of Kura River)
6.	Republic of Azerbaijan and Republic of Armenia under Soviet Union	October 1962	Agreement on the use of water power generation in Arpa River flowing into Lake Sevan
7.	Republic of Azerbaijan and Republic of Armenia under Soviet Union	April 1990	Agreement on controlling discharge in Vorotan River, a tributary of Araks River, the river discharge as of 1990 shared by both countries at the rate of 50:50
8.	Republic of Georgia & Republic of Azerbaijan & republic of Armenia	February 1997 (as a bilateral agreement)	Consultation on monitoring evaluation on the conservation of natural environment / river water conservation of Kura River (though already agreed between Georgia ^ Armenia, still pending between Azerbaijan and Armenia)

Source: Armenia Integrated Water Resources Management Plan (Reference distributed by JICA)

Three (3) Caucasian countries including Armenia participated in the establishment of the Soviet Union in 1922 (independence from the Soviet Union was achieved in 1991), while the republic of Armenia at that time under the Soviet Union and Turkey concluded "Convention on Water Use from Transboundary Rivers, Small Rivers and Brooks of the Union of Soviet and Turkey" in January 1927. It was agreed in this Convention to equally share the quantity of water intake from the Araks River and the Akhuryan River (also called "Arpacay") 50:50, or 1,230 million m^3 per year per country. Besides, in the same year, the Soviet Union planned to construct a head-works in the Araks River, and obtained the agreement of Turkey in which water was shared 50:50 with joint management of the facility after construction. Later, in October 1973, an agreement was also closed to construct a reservoir in the Akhuryan River (at a site of the border between Turkey and Armenia).

All of the above-cited agreements had been closed before the independence of Armenia (1991). However, the stakeholders of SCWE understand they are now still valid. In its background, though no diplomatic relations have not been established yet between Armenia and Turkey, there lies a fact that water sector stakeholders in both countries have regular meetings as to the application of Akhuryan reservoir located between both countries where the share of 50:50 for water use has been identified.

Also, the Akhuryan reservoir was completely constructed in the 1980s during the regime of the Soviet Union, and after the independence of Armenia, it has jointly been utilized. When the reservoir was constructed, it was agreed between both countries that water should be released to Akhuryan reservoir for its conservation with the rate of 150MCM/year for the side of Armenia and 350MCM/year for the side of Turkey in compliance with the share of the territorial watershed area of the reservoir between the two countries. Further, as to the Kaps project, which F/S is on-going, the Government of Armenia is now planning forward by observing releasing volume of 150MCM/year.

2-10 Activities by Other Donors and Their Project Contents

Table 2-10.1 indicates trends of ODA performances to Armenia by five major donors. Amounts of ODA have tended to decrease since 2009 as the total amount, and the amount in 2012 remained at about 50% of the performance in 2008. Year after year, USA and Germany ranked highest for the past 5 years; however, Japan, which occupied a higher rank in the past reduced the amount of ODA to Armenia since 2011.

Table 2-10.1 Trends of ODA Performances by Major Donors (highest five)

unit: million USD

Year	2008	2009	2010	2011	2012
First	USA: 93.8	Japan: 98.7	USA: 91.6	USA: 90.5	Germany :44.9
Second	Japan: 57.7	USA: 78.5	Japan: 77.5	Germany: 40.9	USA :37.6
Third	Germany:27.9	Germany: 31.0	Germany:16.7	Japan: 7.4	France :8.1
Fourth	England: 6.6	France: 5.7	France: 4.5	France: 5.6	Switzerland :3.9
Fifth	France: 5.5	Norway: 3.1	Norway: 3.6	Denmark: 4.2	Norway :3.3
Total amount	208.9	235.0	205.8	164.7	108.4

Source: DAC, International Development Statistics (Since only highest ranked 5 countries were listed, total amount does not match)

The state of external assistance by donors and international organizations since 1994 in the agricultural/ irrigation sector is shown in Table 2-10.2. Major contents of already implemented projects include the existing dams and intake facilities, rehabilitation/improvement of main/branch canals. In addition, the most important task in this sector aims at the shift from pump irrigation to gravity irrigation in almost all rehabilitation/improvement projects. In this context, the background of this issue includes the fact that WUAs in irrigation project areas, in which pumps are the main water sources, are obliged to depend on the government subsidy, and the subsidy also seriously places a heavy burden on the government budget. Besides, the elevated irrigation efficiency brought about by the consolidation of intake facilities and canals leads to reduction of irrigation water consumption. Thus, the envisaged shift to gravity irrigation has a goal to contribute to the conservation of Lake

Sevan, that is, a national policy component.

As to F/S studies, the Kaps irrigation project (assisted by Germany) in the Shirak Marz and the Vedi irrigation project (assisted by France) in the Ararat Marz are currently in the final stage. As for Kaps, it has a main objective of averting risk of dam collapse, but it also envisages lower dependency on pump irrigation. In the case of the Vedi project, the beneficiary of which presently depends on pump irrigation as heavily as 80%, it mainly aims at the conversion into gravity irrigation by means of constructing reservoirs.

In this connection, Germany (KfW) announced that it plans to begin a study on climatic changes and the effect of global warming starting from 2015.

Table 2-10.2 External Assistance by Donors and international organizations for Agriculture/Irrigation Sector

	Name of project	Project outline, target area, perimeter area, beneficiary etc.	Donor	Stage of aid (NR /R*)	Project cost (M.USD)	Project period
1.	Irrigation Rehabilitation Project (IRP)	Emergency assistance project to 8 irrigation project (including 4 reservoirs) in the whole country: the work of rehabilitation was implemented including: total length of canals; 260km, appurtenant structures; 126 sites, total length of drainage canals; 310km and 238 wells.	WB/ IFAD	Implemented (reimbursable)	52	1994 -2001
2.	North-West Agricultural Support Project	Assistance for improving water management techniques in north-western Armenia by participatory approach: Issue extraction on WUA and instruction on efficient water management to WUA were carried out.	IFAD	Implemented (non-reimbursable)	n.a.	n.a.
3.	Two Dam Safety Projects (DSPs) and IDSP (Irrigation Dam Safety Program) II	Rehabilitation project of the existing 74 reservoirs in the country taking account of safety aspect for beneficiary people in their downstream: Safety state of 420,000 beneficiary people in total was improved.	WB	Implemented (reimbursable)	37	2000 -2009
4.	Irrigation Development Project (IDP)	Rehabilitation/ extension of intake facilities in Araks River and main canal with 28km in total length was executed and intake/ conveyance volume was increased from 27 to 53m^3/s. Also, assistance on organization was executed therein, leading to establishment of WUA.	WB	Implemented (reimbursable)	36	2002 -2009
5.	Program of Millennium Challenge in Armenia, Irrigated Agriculture Project	Rehabilitation/ improvement of irrigation systems in the country and strengthening of WUA: Main and secondary/ tertiary canals were improved and the shift from pumping to gravity irrigation was realized in some systems. Also, some pumps were renewed in Ararat Plain and drainage network was improved.	USAID	Implemented (non-reimbursable)	109	2006 -2011
6.	Irrigation Rehabilitation Emergency Project (IREP)	Emergency irrigation facilities rehabilitation project in Aragatsotn & Armavir Marz: Total canal length of 90km was rehabilitated, saving 97MCM/ year (for 8,000ha).	WB	Implemented (reimbursable)	36	2009 -2011
7.	Additional Financing for Irrigation Rehabilitation Emergency Project (IREP)	Emergency irrigation facilities rehabilitation assisting project: Canals were rehabilitated for 110km in total (main canal 58km, tertiary 52km), leading to alleviating conveyance loss by 44MCM/ year.	WB	Implemented (reimbursable)	22	2011 -2013
8.	Construction of Kaps Reservoir and Gravity Irrigation System	A F/S study on the completion of a dam construction of which had been started in 1980s but later suspended in a tributary of Akhuryan River in Shirak Marz, and improvement of the existing irrigation facilities: now the project is put under appraisal, its storage capacity is 25MCM with the beneficiary of 2,280ha, project cost amounting to 94 million USD (Stage-1) as of September 2014. River water is diverted by the dam under suspension during years of Soviet regime where river discharge is released through a water tunnel, but it was choked as it gets dilapidated, thus collapsing risk arises.	Germany (KfW)	F/S Study (non-reimbursable)	n.a.	2012 -2014
9.	Construction of the Vedi Reservoir for Irrigation in the Ararat Valley	F/S study on dam construction and improvement of the existing irrigation system in Vedi River in Ararat Marz: it's now on the way to report finalizing stage (as of September 2014), with the maximum water storage of 40MCM, beneficiary perimeter of 2,820ha, project cost amounting to 197million USD (Option-2 but also another option exists). Though 77% of the intake volume of the existing irrigation system presently depend on pumps, the project mainly aims at shift from pump irrigation system to gravity one.	France (AFD)	F/S Study (non-reimbursable)	n.a.	2012 -2014
10.	Toward Integrated Water Resources Management: Revisited	The first edition was published in 2002 targeting to the whole country. Based on change in water resource environment after 2002 and also on the result of review study in 2014 as well as current state of irrigation, the revised edition suggests future outlook of water resources and irrigation strategy.	WB	Policy assistance F/S Study (non-reimbursable)	n.a.	2013 -2014

Source: Document of reply from Armenia to the JICA questionnaire, also. F/S reports of Kaps、Vedi irrigation reports

*NR/R: non-reimbursable / reimbursable.

CHAPTER 3 CURRENT STATUS OF THE YEGHVARD IRRIGATION DEVELOPMENT PROJECT AREA

3-1 Natural Conditions

The Yeghvard irrigation project extends over the western part of the Hrazdan River. The elevation of the planned site for the Yeghvard reservoir is about 1,300m, while the beneficiary area develops over the elevation range of 800m-1,300m. The Kasakh River originates at Mount Aragats and flows in the center of the project site. The Arzni-Shamiram Yeghvard canal flowing at the northern part of the irrigation development project area is an open canal from its intake point at the Hrazdan River at the elevation of about 1,400m to the terminal point at the elevation of around 1,250m. The lower Hrazdan canal stems from its intake point at the Hrazdan River, the elevation of which is about 1,000m, flowing to its terminal point, the elevation of which is around 850m. The Yeghvard irrigation development project is located administratively at Kotayk Marz, Aragatsotn Marz and Armavir Marz.

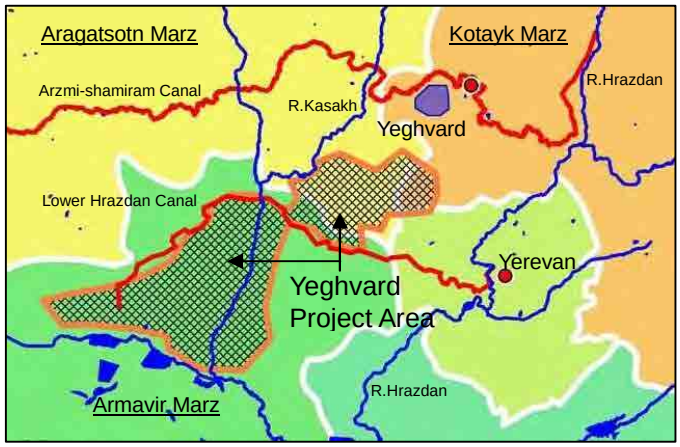


Figure 3-1.1 Location Map of Yeghvard Project and Related Marz

3-1-1 Meteorology

Monthly meteorological data for the past three (3) decades have been collected (covering precipitation, atmospheric temperature, relative humidity, wind velocity and evaporation). The collected data are shown in the Appendix D-2. Figure 3-1.2 indicates the annual precipitation and mean annual rainfall for 30 years as observed at the Hrazdan meteorological observatory installed in the watershed area of said river (see Appendix D-3). Also, Figure 3-1.3 gives differential values of annual precipitation for individual years (shown as a line chart graph) from the average annual precipitation for 30 years (722mm) and with an approximated curve. As compared with the annual precipitation recorded during the 1990s, it is clear that it tends to be higher during the 2000s than in previous decades.

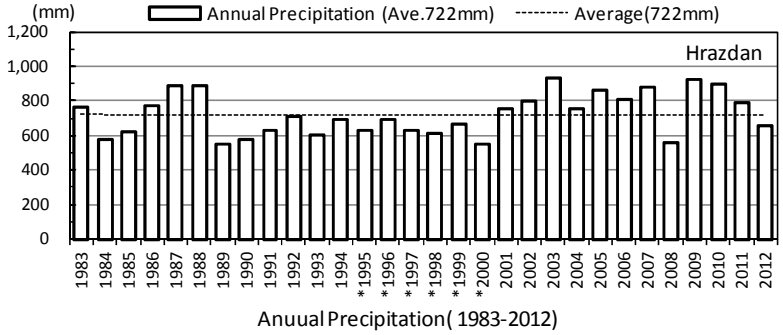


Figure 3-1.2 Annual Precipitation Measured at Hrazdan Observatory Point

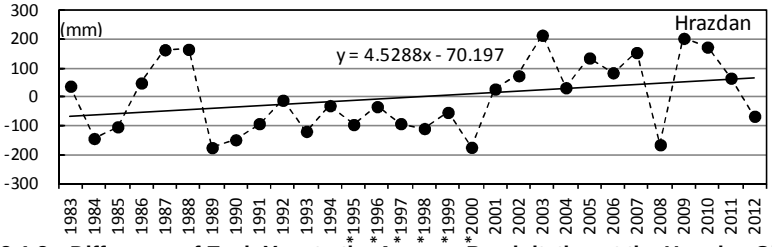


Figure 3-1.3 Difference of Each Year to the Average Precipitation at the Hrazdan Observatory

Figure 3-1.4 indicates the monthly means of average atmospheric temperature, precipitation and evaporation for the past 30 years at the Hrazdan observatory (altitude: 1,765m) and the Yeghvard observatory (altitude: 1,337m). As for precipitation, it shows its peak season in April and May, then reduces towards August. As for evaporation, the peak falls in June with values outweighing precipitation having been observed during summer. In this regard, a 30-year mean value of annual precipitation at the Hrazdan observatory is 722mm, while that at the Yeghvard observatory records 445mm.

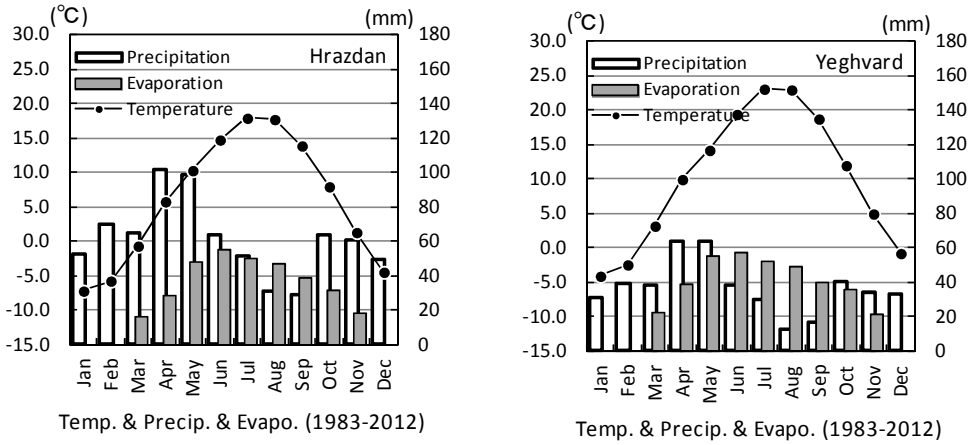


Figure 3-1.4 Meteorological Features at Hrazdan Observatory and Yeghvard Observatory

A probability calculation is attempted in order to clarify the feature of precipitation. As a result of this calculation, out of a calculated standard period for 30 years (1983-2012), 2008, that is the latest drought year, indicates a return period of 1/13 (with a confidence of 92%), while another drought year, 2012 has a return period of 1/4 (with a confidence of 67%). Considering this, for precipitation recorded after 2000, an increasing tendency is observed in annual precipitation. When the calculation is attempted targeting the latest decade (2003-2012), 2008 assumes a return period of 1/65 (with a confidence of 98%), while 2012 shows 1/8 (with a confidence of 88%), indicating that 2008 is deemed as exceedingly rare, or a severe drought year.

Table 3-1.1 Probability Calculations for 2008 and 2012 Targeting the Observed 30 Consecutive Years

Year	Probability (%)	Return Period
2008	92 %	1/13
2012	67 %	1/4

Table 3-1.2 Probability Calculation of 2008 and 2012 Targeting Latest Decade

	Probability (%)	Return Period
2008	98 %	1/65
2012	88 %	1/8

3-1-2 Hydrology (monthly data)

River discharge data have been collected at three (3) observation points on the Hrazdan River and one (1) point on the Kasakh River. The collected data are shown in the Appendix D-4. Figure 3-1.5 shows the total discharge of the Hrazdan River, obtained by adding the observed discharge of the Hrazdan observatory to that of the Lusakert observatory, while Figure 3-1.6 presents discharge data of the Kasakh River as observed at the Ashtarak observatory. As evident from the past three (3) decades, fluvial discharge data, discharges in both of these rivers, sharply augments in April/May, and thereafter the state of reduced discharges recurrently appears. The latest records related to this (covering 2003-2012) are shown in Figure 3-1.5 and Figure 3-1.6 with the rest of the data being listed in the

Appendix D-4.

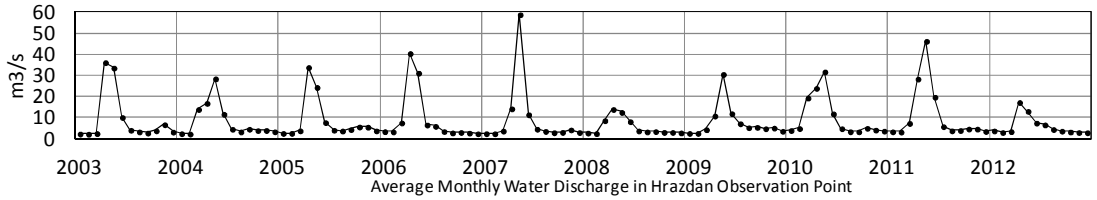


Figure 3-1.5 Discharges in Hrazdan River (2003-2012)

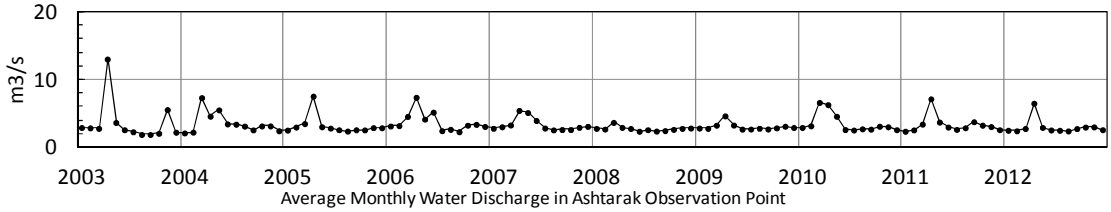


Figure 3-1.6 Discharges in Kasakh River (2003-2012)

3-1-3 Hydrology (10-days data)

The water supply from the Hrazdan River to the main canal has been managed by the WSA (Water Supply Agency), while the irrigation system, including secondary canals and further downstream, has been done by WUA (Water Users Association), and the minimum period in this water management is made according to the data of 10-days average. In this study the 10-days data of river discharges for a decade (2003-2012) were collected so that they can reflect the real state of the latest discharges (see Appendix D-5). Figure 3-1.7 gives the 10-day discharges of the Hrazdan River (equal to the sum of observed values at both the Hrazdan and Lusakert observatories), and those of the Kasakh River (recorded at the Ashtarak observatory). Each of these three curves represents a discharge of 50% probability draught discharge (return period of 1/2), 75% probability draught discharge (return period of 1/4) and 90% probability draught discharge (return period of 1/10), respectively. In both Hrazdan and Kasakh Rivers, it is observed that the river discharges start to rise up from around mid-March and reach their maximum rates during the period of April-May.

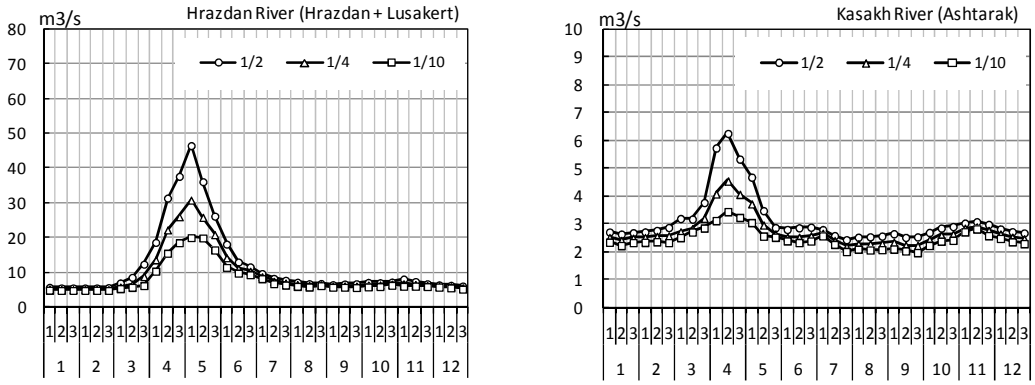


Figure 3-1.7 10-days Fluvial Discharge in Hrazdan River and Kasakh River

3-1-4 Water Resources

Figure 3-1.8 indicates the breakdown of water volume supplied from the Hrazdan River and Lake Sevan. According to the collected data, the water level of Lake Sevan has shown a rising tendency since 2002. Water flows into Lake Sevan through natural streams and also is conveyed by means of the

Arpa-Sevan water tunnel (diverted water volume amounted to 240MCM as a performance record in 2010). The upper limit of water volume that can be supplied from Lake Sevan is 170MCM, except during drought years.

However, judging from the figure shown on the left in the Figure 3-1.8, the water supply during two drought years, 2008 and 2012, outweighed 170MCM, implying that these years experienced a severe water shortage. In this context, since a water shortage condition is likely to prevail again in 2014, the Government of Armenia raised the upper limit of water use in Lake Sevan in August, 2014 from the usual level of 170MCM to 270MCM.

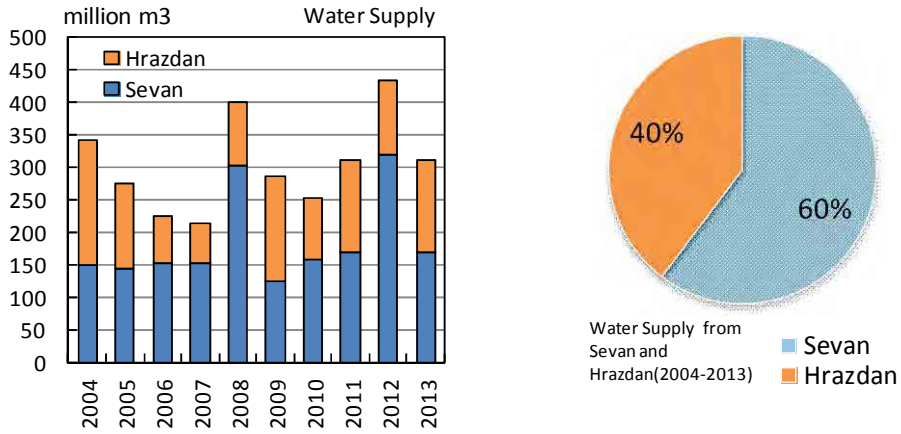


Figure 3-1.8 Water Use Situation in Irrigation and Rate of Supply Sources, Hrazdan River and Lake Sevan

3-2 Agriculture and Farm Management

3-2-1 Agricultural Production

While the Yeghvard Irrigation Project has a plan to irrigate about 12,200ha of land, there is no specific agricultural statistical data for the area to be irrigated. Therefore, the present agricultural production in three Marzes, i.e. Kotayk, Aragatsotn and Armavir, where the target irrigation area extends, is explained below based on various agricultural statistical data in Sub-chapter "2-3 Agriculture Sector". Out of the total target area of 12,200ha, 2,428ha (19.9%), 1,739ha (14.3%) and 8,033ha (65.8%) are located in the Kotayk Marz, the Aragatsotn Marz and the Armavir Marz, respectively. The farming structure in the total area is similar that of the Armavir Marz, since the target irrigation areas in the Kotayk Marz and the Aragatsotn Marz border on the Armavir Marz.

1) Kotayk Marz

There were 37,620 farm-households and 41,649ha of farmland in the Kotayk Marz in 2006. The average farmland per farm-household is 1.11ha. Crop diversification is not well advanced, as the cereal production area occupies more than half of the total farmland. The orchard area is the next largest after the cereal area. Productivity of major crops in this Marz is lower than the national average and the lowest among the three Marzes, since the Marz has the least favorable farming conditions among the three Marzes. With respect to raising livestock, poultry breeding is popular, and the Marz is an egg-production area in Armenia. However, the poultry production area in the Marz is located out of the target area.

2) Aragatsotn Marz

There were 37,165 farm-households and 58,159ha of farmland in the Aragatsotn Marz in 2006. The average farmland per farm-household is 1.56ha. The Aragatsotn Marz is a production center of cereals

in the country. The cereal production area occupies more than a half of the total farmland, the same as the Kotayk Marz. The areas of fodder crops and fruits are relatively large in this Marz. The percentage of grape area is also relatively high. Productivity of major crops in the Marz is almost equal to the national average. With respect to raising livestock, cattle breeding and sheep/goat breeding are popular. The raising of livestock is an important pillar of farm income in the Marz together with cereals. Grape production is quite dominant in the target irrigation area in this Marz as well, so cereals farming and the raising of livestock are combined with the grape production.

3) Armavir Marz

There were 50,347 farm-households and 47,577ha of farmland in the Armavir Marz in 2006. The average farmland per farm-household is 0.95ha. This Marz, together with Ararat Marz, is the largest production area of vegetables, fruits and grapes in the country. Intensive farming is well introduced among farmers since the average farmland is relatively small. The farmland area for cereals occupies only less than 20% of the total farmland area. With favorable soil and weather conditions, this Marz is a national leading Marz in the productivity of major crops. Though the raising of livestock is not well practiced compared with crop farming, pig breeding and poultry farming are popular among farmers. This Marz is the largest egg-producer in Armenia.

3-2-2 Crop Production and the Technology Level

As explained above, there is no specific agricultural statistical data for the target irrigation area. PIU has data about the planted area of crops for the area in 2013 (see Table 3-2.1). While there are five (5) WUAs which have command areas extending into the target irrigation area, the Yeghvard WUA belongs to the Kotayk Marz, the Ashtarak WUA belongs to the Aragatsotn Marz and the remaining three (3) WUAs belong to the Armavir Marz. Out of about 12,200ha of the target irrigation area, only about 9,220ha was irrigated in 2013. Since it is impossible to grow crops without irrigation on a commercial scale in the area, the irrigated area is equal to the planted area. About 79% of the planted area extended across three (3) WUAs in the Armavir Marz in 2013.

Table 3-2.1 Planted Area by Crops in the Project Area in 2013

Name of WUA		Farmland in Cadaster (ha)	Planted Area/Irrigated Area (ha)						
			Wheat	Vegetables	Grape	Orchard	Perennial grass	Others	**Total**
1	Yeghvard	2,428	152.0	53.0	76.0	348.0	213.0	208.4	**1,050.4**
	%	-	(14.5)	(5.0)	(7.2)	(33.1)	(20.3)	(19.8)	**(100.0)**
2	Ashtarak	1,739	109.0	81.0	416.0	69.0	67.0	174.0	**916.0**
	%	-	(11.9)	(8.8)	(45.4)	(7.5)	(7.3)	(19.0)	**(100.0)**
3	Vagarshapat	639	294.0	197.0	9.0	25.0	23.0	57.0	**605.0**
	%	-	(48.6)	(32.6)	(1.5)	(4.1)	(3.8)	(9.4)	**(100.0)**
4	Khoy	5,236	1,107.0	1,222.0	766.0	523.0	347.0	1,128.0	**5,093.0**
	%	-	(21.7)	(24.0)	(15.0)	(10.3)	(6.8)	(22.1)	**(100.0)**
5	Aknalich	2,158	362.0	554.0	96.0	25.0	188.0	331.0	**1,556.0**
	%	-	(23.3)	(35.6)	(6.2)	(1.6)	(12.1)	(21.3)	**(100.0)**
Total		**12,200**	**2,024.0**	**2,107.0**	**1,363.0**	**990.0**	**838.0**	**1,898.4**	**9,220.4**
%		-	**(22.0)**	**(22.9)**	**(14.8)**	**(10.7)**	**(9.1)**	**(20.6)**	**(100.0)**

Source: PIU, the State Committee of Water Economy

The percentage of planted areas of wheat, vegetables, fruits (including grape) and others (forage cereals, potato, etc.) are in a similar range to the target irrigation area in 2013. The crop diversification is well advanced in the area. The planted area of each WUA is summarized as follows.

- Yeghvard WUA: High percentage of orchard and perennial grass (Alfalfa), and low percentage of vegetables and wheat
- Ashtarak WUA: High percentage of grape, and low percentage of vegetables and wheat

- Vagarshapat WUA: High percentage of wheat and vegetables, and low percentage of fruits and others
- Khoy WUA: All kinds of crops are equally planted. Representing the cropping in the target irrigation area
- Aknalich WUA: High percentage of vegetables and low percentage of fruits

While a cropping calendar of major crops is compiled in Appendix-B, the cropping seasons of major crops are almost equal to the seasons illustrated in Figure 2-3.2. Almost all crops are planted with the coming of the spring season (April–May) and harvested in July/August, though wheat, which is a staple diet of the Armenian people, is sown in the autumn season. Some vegetables are popularly grown in an earlier season (than spring) by tunnel or greenhouse culture. The drip irrigation system and greenhouses are widely accepted by farmers in the Amarvir Marz. It is evaluated that the technology level of farmers in the target irrigation area is considerably high. Appendix-B also shows the productivity of major crops, which is self-reported by farmers. The relatively high productivity might be a proof of higher farming technology of farmers in the target irrigation area. However, most of the farmers are only interested in production technologies, and they are little concerned for technologies about the safe use of agricultural chemicals or the safety and security of farm products. This issue should be addresses by the government with future agricultural extension programs.

3-2-3 WUA (Water Users Association)

The target irrigation area extends across the command areas of five (5) WUAs, while the command area of each WUA contains the non-target irrigation area. As shown in Table 3-2.2, there are 27 communities and 11,179 WUA members in the area. As the average number of family members is estimated to be five (5), there are about 56,000 farmers and their family members in the area. While the total farmland area registered in the cadaster is about 12,200ha, the actual irrigated area was 9,220ha in 2013. The average irrigated area per WUA member was 0.82ha in 2013. The irrigated area ratio (actual irrigated area/farmland area in the cadaster) is calculated to be 5.6%. The ratio will be 100% after completion of the Yeghvard Irrigation Project.

Among the 5 WUAs, the Khoy WUA occupies the largest farmland area (about 1/2 of the total), and has the highest irrigated area ratio. As explained in “sub-chapter 3.2.2”, a cropping pattern in the Khoy WUA is similar to the pattern in the target irrigation area. The Khoy WUA shall be the representative WUA in the area.

Table 3-2.2 WUAs in Yeghvard Irrigation Project Area

No.	WUA	Number of Communities	WUA Members	Farmland in Cadaster (ha)	Irrigated Farmland 2013 (ha)	% of Irrigated Farmland	Irrigated Farmland per Member(ha)
1	Yeghvard	3	1,194	2,428	1,050.4	43.3	0.88
2	Ashtarak	4	1,716	1,739	916.0	52.7	0.53
3	Vagarshapat	3	878	639	605.0	94.7	0.69
4	Khoy	13	5,378	5,236	5,093.0	97.3	0.95
5	Aknalich	4	2,013	2,158	1,556.0	72.1	0.77
Total		**27**	**11,179**	**12,200**	**9,220.4**	**75.6**	**0.82**

Source: PIU, the State Committee of Water Economy

3-2-4 Farmers’ Problems

A series of workshops were held during the study with four (4) groups consisting of WUA members and WUA staff members in the target irrigation area. In the each workshop, a problem analysis was made in a participatory manner with the core issue of “Income from farming is not enough”. After the problem analysis, a problem tree was made for each group. Farmers’ problems related to farming,

including irrigation for each group, are arranged on the problem tree. An outline of the four (4) groups who participated in the workshops is shown in Table 3-2.3.

Table 3-2.3 Outline of Selected Groups for WUA Workshop

No	Date	Group	Community	Total Area (ha)	Irrigated Area (ha)	Irrigated %
1	July 24, 2014 (Thu)	Khoy WUA (1) (Plain area, canal irrigation dominant)	Aragats	452.7	587.0	129.7
			Tsahkalanj	312.0	477.0	152.9
2	July 25, 2014 (Fri)	Khoy WUA (2) (Plain area, canal irrigation dominant)	Samaghar	532.6	469.0	88.1
			Haytagh	647.6	425.0	65.6
3	July 29, 2014 (Tue)	Aknalich WUA (Plain area, pump irrigation dominant)	Taronik	404.9	286.0	70.6
			Aratashen	723.8	651.0	89.9
4	July 30, 2014 (Wed)	Yeghvard WUA (hilly area, canal irrigation dominant)	Kasaak	634.0	301.0	47.5
			Proshyan	1139.7	336.4	29.5

Source: The JICA Study Team

Based on the workshop result, it appears that farmers in the target irrigation area share the following common issues, though the seriousness of each issue slightly differs from group to group. The detailed report of each workshop is attached in Appendix-B.

1) Lack of technical consultancy services and government support

Many farmers consider that they do not have enough technical consultancy services for farming from the Government. Their stated problem is that they do not have a local agricultural specialist to provide consultation on farming, such as efficient and effective input use, insects and diseases control, etc. According to the Ministry of Agriculture, several agricultural extension programs are provided to farmers through ASMC. However, the programs may not meet a need of end-farmers. In addition to the extension programs, the Government has several supporting services which provide seeds, fertilizers and chemical spray service to farmers. Nonetheless, similar to the extension programs, many farmers are not satisfied with the supporting services. However, it is true that there are substantial numbers of farmers who still hold views that glorify socialism. Many farmers still consider that an agricultural extension service means the same as a provision of supporting goods from the Government.

2) High production costs (inputs, irrigation, etc.)

Prices of seeds, fertilizers, insecticides, etc. increase every year, while the farm-gate prices of vegetables and fruits, which are major income sources of farmers who participated in the workshop, have been disappointing to them during recent years. Many farmers say that their benefits from farming have decreased due to the increased prices of inputs and the stagnant prices of the products. They also say that the irrigation fee is also not affordable for them.

3) Low quality of agricultural inputs

Many farmers complain about the unreliable quality of agricultural inputs available in the Armenian market. They say that seeds are sometimes not well germinated, or insecticides and fertilizers are not effective while their prices are high. Such quality-related problems may promote farmers' dissatisfaction with the prices. It is probably true that some farmers misuse the inputs. There could be, however, another reason, such as, the quality of agricultural inputs may be not well supervised or might be controlled by low standards

4) Degradation of soil fertility

Several participating farmers say that the soil fertility of their fields has gradually deteriorated. However, many of the farmers cannot explain the reasons of the degradation logically. It is deemed

that the farmers have difficulty understanding the reasons, since the soil degradation occurs due to multiple factors. A small number of farmers have offered reasons such as improper crop rotation practice and insufficient tillage.

5) Lack of farm machinery (Tractors)

A substantial number of participating farmers complained about the insufficient number of farm machinery, especially tractors. Farmers say that it is difficult to use tractors on time when necessary due to the insufficient numbers, as well as the aging of the machinery. According to information from the Ministry of Agriculture, there is (theoretically) an optimum number of tractors and combine-harvesters, considering the cultivated area in Armenia. However, farmers have a different sense from the theory about the amount of farm machinery. It is supposed that an operation system of tractors and other farm machinery does not do much for the fragmented farmland caused by the land reforms after independence.

6) Lack of irrigation water (undeveloped end canals, poor management of canals and deduction of groundwater level) and degradation of water quality

Irrigation is the greatest concern for most farmers, since it is almost impossible to grow crops without irrigation in the target irrigation area. It is, however, interesting that even the participants of the Koy WUA (1), who are getting more than a sufficient amount of irrigation water (see Table 3-2.3), claim to have a serious problem of shortage of irrigation water. It must be necessary then to give in-depth consideration to this problem in future studies. Many farmers consider that undeveloped end canals is the principal cause of the shortage of irrigation water. It is supposed that the networks of end canals are not well developed in accordance with the farmland fragmentation. There are many farmers who depend on groundwater that is pumped up by tube-wells managed by respective WUAs in the Khoy and Akhnalich WUAs. Many of them have a problem of decreased groundwater levels causing a decreased volume of water from the tube-wells and an increased electricity cost for the tube-wells. Some farmers claim that the water quality is getting worse due to garbage in rivers and main canals. However, an actual influence of the water quality deterioration to their crops is not clear according to the farmers' explanation. It is also necessary to give in-depth consideration to this problem in future studies.

7) Lack of accessible agricultural credit (high interest rate and short repayment term)

In order to alleviate the influence of the increasing production costs, farmers are interested in an agricultural credit system. With such a system, the Government would compensate farmers for a part of the interest of agricultural credit by its supporting scheme. Many farmers, however, feel that the present agricultural credit system is not practical for them. Farmers recognize that a high interest rate and a short repayment term, considering the production cycle, are major obstacles for them to be able to access the agricultural credit. In addition to these issues, the farmers' inadequate knowledge of the credit system may be another reason why it is not useful for them.

8) Natural disasters (hail and low temperature)

While many farmers suffer from hail damage during the study period in the target irrigation area, they have damage every year according to the participating farmers. Though the Government has taken measures to deal with hail damage by installing an anti-hail system in several areas, the system still has a limited effect at the field level. Many farmers also report to have had damages related to unusually low temperatures during the early spring season. In fact, they suffered from serious damages to the apricot crop this year. Consequently, many farmers hope to have the Government's support regarding this, including an insurance system to address the disasters.

9) Marketing (low selling price, lack of good buyers and poor road condition)

As described in "sub-chapter 2-3-11", many farmers consider that a stagnant price of farm products, especially vegetables, is a major serious problem for their farming business. According to a market price survey carried out by the JICA study team, vegetables fluctuate widely in price and the prices decline sharply during July-August, which is the peak harvesting season. Vegetable production has already saturated the domestic market during the peak harvesting season, since the production has sharply increased in recent years and the per capita supply is more than 300 kg/year, which is the highest in the word. Due to such a background, many farmers have a bitter experience in the marketing of vegetables, i.e., low prices as well as unsold products. Though there are farmers who can take their products to the Yerevan market for selling, such self-marketing is not easy for general farmers. According to farmers who did this at the Yerevan market, the net profit between the self-marketing and ordinary marketing at the farm-gate was not much different considering transportation and handling costs, leftover losses, etc. In addition, the poor rural road condition is also an impediment to smooth marketing according to the participating farmers.

The nine above-mentioned issues are arranged in a problem tree as shown in Figure 3-2.1. Also, as shown in Table 3-2.4, the participating farmers have serious concerns related to the irrigation issue and the marketing issue. According to the farm-household survey also carried out by the JICA study team separately covering four (4) Marzes, the marketing issue, especially low selling-prices and a sharp fluctuation of the prices, is the most serious problem of sample farmers in all Marzes. It is supposed that marketing is the most serious common issue among Armenian farmers.

Table 3-2.4 Serious On-farm Problems Raised by WUA Members

Group	Serious Problem Subjects		
	1st	2nd	3rd
Khoy WUA (1)	Shortage of water	Marketing of products	State extension/ Govt. supports
Khoy WUA (2)	Irrigation water	Marketing of products	Tractors
Aknalich WUA	Irrigation water	Marketing of products	Seeds
Yeghvard WUA	Seeds	Irrigation system	Marketing of products/ Soil fertility

Source: The JICA Study Team

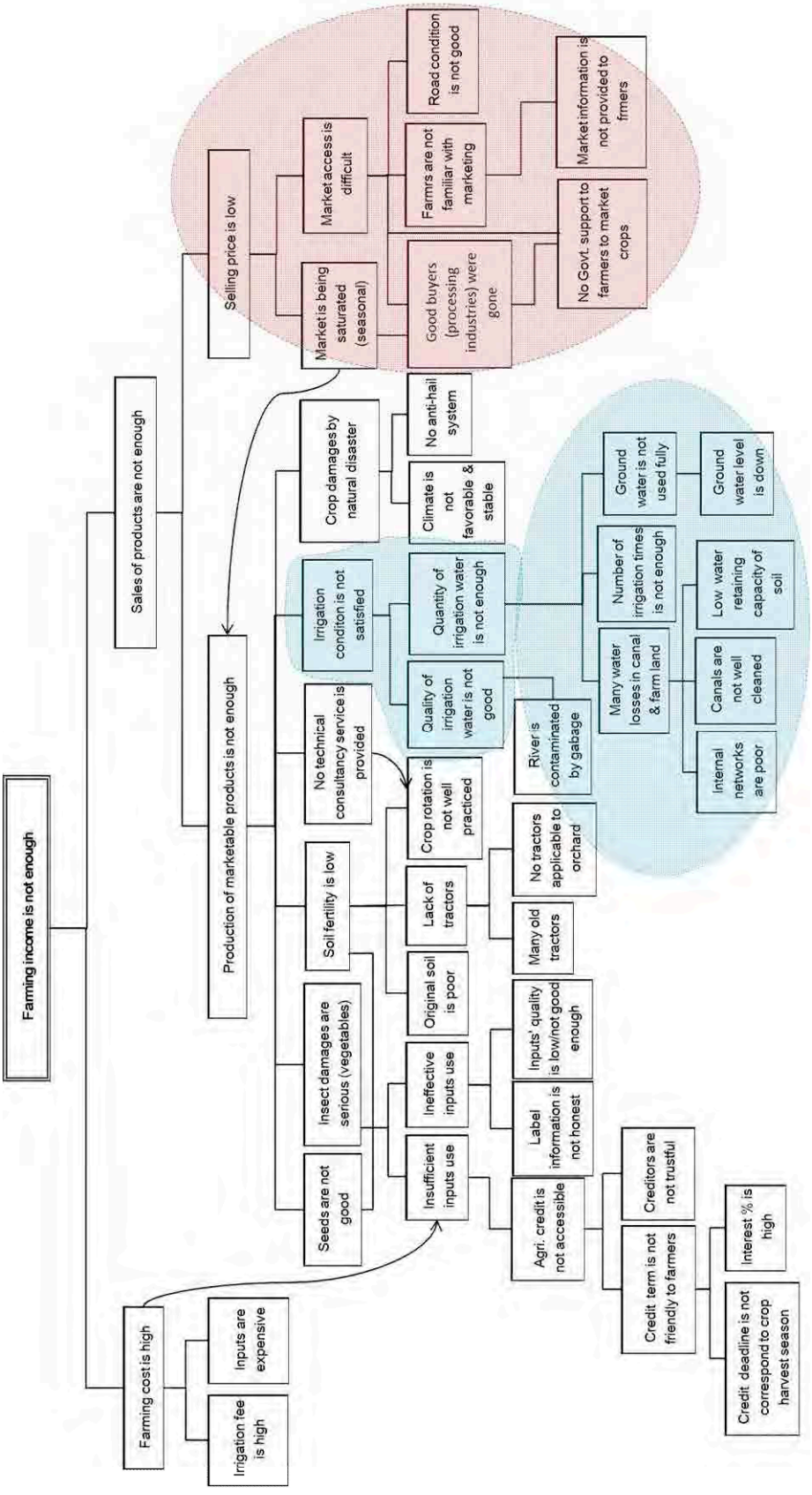


Figure 3-2.1 Problems of Farmers in Yeghvard Irrigation Project Area

3-3 Plan of Yeghvard Irrigation Development Project

3-3-1 Geological Investigation

1) Previous geological investigation

Geological investigation on the Yeghvard Plateau commenced long ago in relation to the volcanic mountains. The first systematic geological investigation on the Yeghvard reservoir was carried out from 1931 to 1932. In 1940, an additional geological investigation in the planed reservoir area was conducted by the "TVIAGIDEP" Institute of the ex-USSR, and the need of counter measurement for infiltration was reported. During the period from May 1958 to August 1960, another institute (ArmHydroEnergoProyekt) conducted a series of engineering geological surveys to justify the design of the Yeghvard reservoir. At this time, some geophysical prospection (mainly vertical electric sounding: VES) and many permeability tests were conducted, and a geological map near the dam site was drawn up; however, the soil's physical and mechanical properties were not yet tested.

After this, there was a long remoteness of more than 25 years. Then, in 1979, the "GiproVodStroy" Design Survey Institute conducted a systematic geological, hydrogeological, and geophysical investigation for the F/S on the Yeghvard reservoir (reported in 1980). Finally, from March 1983 to May 1984, the "ArmGiproVodxoz" State Design Institute performed again a large scale systematic geological, hydrogeological, and geophysical investigation for the Detail Design Study (D/D) of the Yeghvard reservoir (at this time the planed reservoir capacity was 228 MCM). The report was issued in 1980.

Table 3-3.1 shows a summary of the geological investigation works carried out in the above mentioned F/S and D/D at the Soviet time. As shown in the table, starting from a field geological reconnaissance survey, nearly 7,660m of core-boring, around 600m of test-pits and trench excavation, and 340 points of VES, were conducted only for the reservoir area in the D/D stage. When the investigation for the canal routes and pumping stations were included, the work volume must have been of an abnormally huge amount as an investigation for only one dam project.

Figure 3-3.1 in the next page shows a geological map (1:5,000 scale) and locations of geological investigation conducted in the D/D stage.

Tab-3.3.1 **Quantities of Geological/Geophysical Investigation Work**

No.	Activity	Quantity		Unit
		F/S	D/D	
1	Geological Reconnaissance Survey			
	(Damsite, 1:5,000. scale)	2	12	km^2
2	Geological Reconnaissance Survey			
	(Canal, roads,and others, 1:5,000. scale)	–	45	km^2
3	Core Boring for Damsite Investigation			
	a) By "ArmGiproVodKhoz" Institute	1,152.0	4,510.4	(run) m
	b) By "ArmGIIGIS" Institute		1,443.0	(run) m
4	Core Boring for seismic micro-zoning			
	By "ArmGiproVodKhoz" Institute	–	209.7	(run) m
5	Non-core Boring for Damsite	344.3	–	(run) m
6	Core Boring 3			
	(for pumping station and canal route)	–	1,150.0	(run) m
7	Test Pit Excavation			
	(in the reservoir area)	32.2	435.8	(run) m
8	Trench Excavation			
	(in the reservoir area)	–	135	(run) m
9	Water Filtration Test			
	a) Pouring/injection tests in boreholes	44	145	times
	b) Pouring tests in Test Pits	2	52	times
10	Lithological Logging			
	(for boreholes)	51	290	holes
11	Geophysical Prospectings			
	a) Vertical Electrical Soundings			
	(Reservoir area, AB=2,000m)	–	150	points
	b) Vertical Electrical Soundings			
	(Quarry site, AB=2,250m)	–	190	points
	c) Geoelectric Borehole Loggings	–	300	(run) m
	d) Vertical Electrical Soundings			
	(Interfluve area, AB=3,000m)	–	70	points
	e) VES Interpretations	–	410	points
12	Soil/Rock Sampling for Laboratory Test	194	123	samples

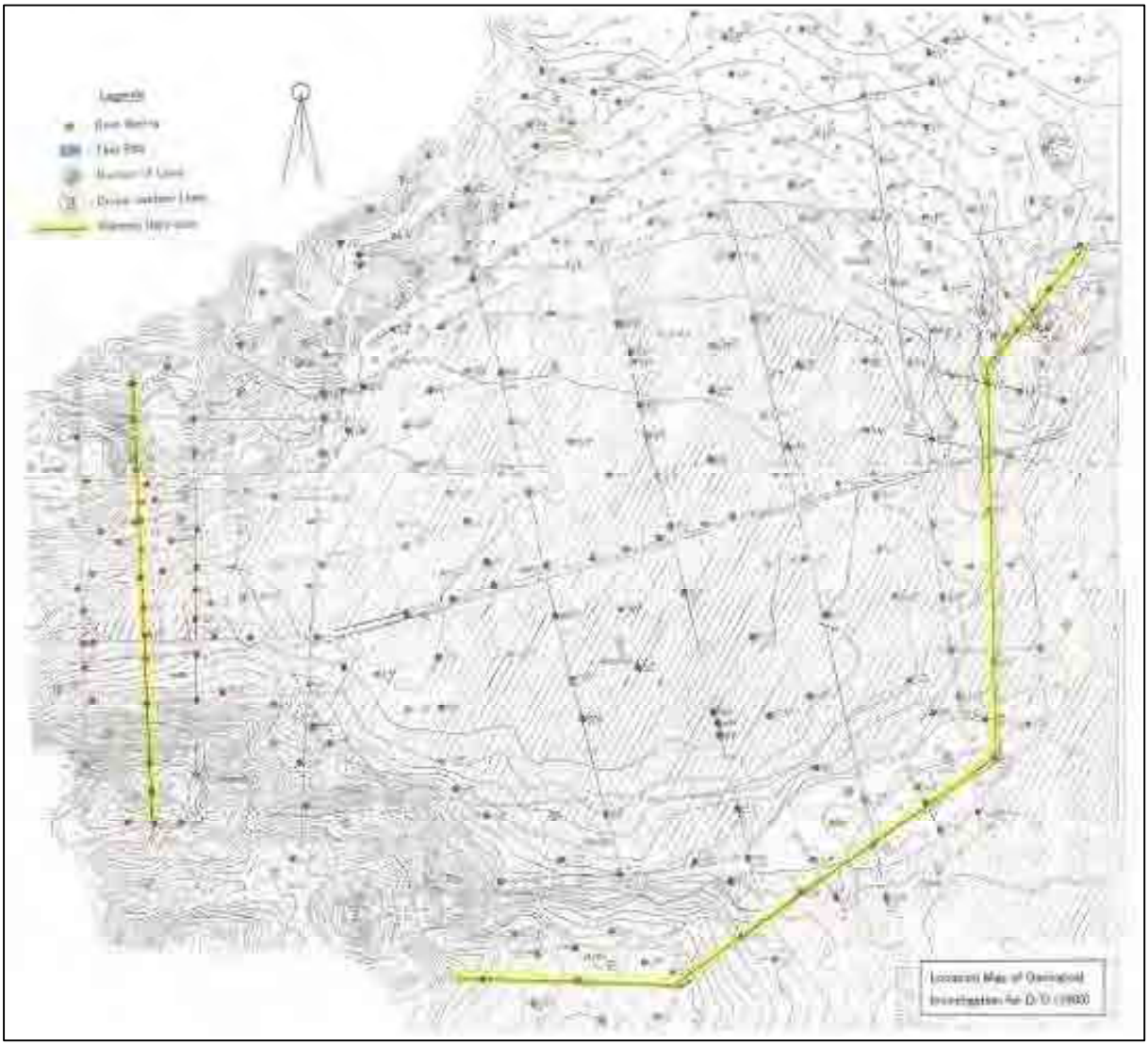


Figure 3-3.1 Locations of Geological Investigation

2) Topography and geology of Yeghvard area

The proposed Yeghvard reservoir is located in the Kotayk Region, at almost the center of northern Armenia. The reservoir is situated at around 16km north from Yerevan, the capital of Armenia, and 3.0km southwest from the Yeghvard Town

The planned Yeghvard Reservoir is situated in the western part of a volcanic and middle height "Yeghvard Plateau", at an elevation from 1,200m to 1,400m and the plateau is located directly south of the Mount Arailer (2,821m). In the west, the plateau abruptly terminates in the deep gorge (120-150m depth) of the Kasakh River while in the east it terminates in another deep canyon of the Hrazdan River.

The Yeghvard Basin where the Yeghvard reservoir is planned to be constructed is situated in the west of the said plateau. The greater length of the basin is around 4.5km, and the width is 3.5km; the water surface area of the reservoir was about 1000ha in the original plan (228 MCM). The hydrographical network of the study area is very weakly developed. The Yeghvard Basin has neither constant water flow nor a pond. There are only small temporary water flows, which are formed on the sides of the basin from rainfall and snow melt water. Such small temporary water flows discharging into the Kasakh River. The Kasakh River gorge is a natural drain for all surface and groundwater in the region.

The geological setting of the study area, near around the Yeghvard reservoir, consists of the Neogene Tertiary and Quaternary. The basement of the area is, practically, Miocene Sediments referred to as the "Hrazdan Suite", mainly consisting of sandstone, shale, and marls, with the bedding at a depth of 210-230m. The washed-out surface of the Hrazdan Suite was covered by a Pliocene dacite laver, andesite lavers, old river deposits, and volcanogenic scoria formations. These volcanogenic formations are cropping out in the hills surrounding the reservoir or bedded under the new sediments in the bottom of the reservoir.

In the Quaternary age, again much volcanic activity brought several volcanogenic formations, such as andesitic lavers, tuffs, scoria, and pumices, to the area, and when the volcanic activities intermitted some alluvial sediment was deposited covering those volcanic formations. As of recent, alluvial fans of Aeolian and lacustrine sediments are still accumulating. Most of the alluvial sediments are covering the bottom of the planned reservoir or along the slopes some of the time.

The general stratigraphy in the study area is shown in Table 3-3.2.

Table 3-3.2 General Stratigraphy in the Study Area

Table-3.3.2 General Stratigraphy of Yeghvard Area

Age			No.*	Mark*	Lithology	Thickness	Note
Quaternary	Holocene		①	$_{Vdp}Q_{IV}$	Aeolian-Diluvial-Proluvial Formation	35-40m	
			②	$_{pa}Q_{IV}$	Proluvial-Alluvial Sediments	2-27m	Embank materials
			③	$_{ed}Q_{IV}$	Eluvial and Deluvial Sediments	1-5m	
	Pleistcene	Upper	④	βQ_{III}	Volcanogenic Formations	5-25m, 30m	
		Middle	⑤	βQ_{II}	Volcanogenic Formations	10-50m	
			⑦	$_{lap-ap-lap}Q_{I-II}$	Alluvial-Proluvial-Lacustrine Sediments	110-120m***	
		Lower	⑪	βQ_{I}	Lithoidal Pumices	10m	
			⑫	βQ_{I}	Volcanogenic Pyroclastic Tuffs	<10m	no-outcrop**
Tertiary	Pliocene		⑬	βN_2	Volcanogenic Scoria Formation	100-150m	
			⑭	αN_2	Pliocene Alluvial Sediments	40-150m	no-outcrop
			⑮	$\alpha+\beta N_2$	Olivine Basaltic Andesite	50-160m	
			⑯	αN_2	Hornblend-Hyperthene Andesite	50-160m	no-outcrop
			⑰		Pliocene Dacites	100-300m	
	Miocene			N_1	Sarmation Sediments (Hrazdan Suite)	300-350m	no-outcrop

*: marks in Geological map/Cross section.
: unconsolidated sediments
**: no-outcrop in Damsite.
***:total depth with ④layer..

3) Hydrogeological condition of Yeghvard area

The hydro-geological condition of the area is quite simple; it is composed of the Miocene sediments as an impervious basement, and volcanogenic formations and unconsolidated sediment after Pliocene as a pervious over cover.

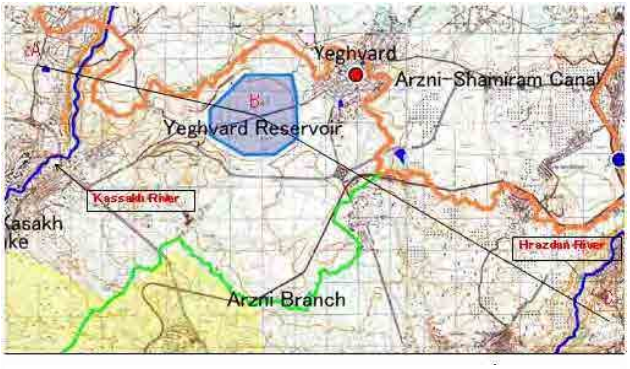


Figure 3-3.2 Guide Map of Yeghvard Basin

The bottom of the planned area of the Yeghvard reservoir is widely covered by unconsolidated alluvial deposits, consisting of sand-and-gravel/pebble of very pervious and loamy sand and/or loam layers with slightly low permeability. The slopes surrounding the

reservoir consist of volcanogenic formations such as lava flow, tuffs, scoria, and pumices, having very high permeability.

At the dam site, there is no permanent river flow and no perennial pond, and it means rain water supplied in the reservoir area is immediately infiltrated into the ground. The depth of the impervious basement is said to be 210-230m from the ground surface, suggesting that it is very difficult to a form groundwater aquifer in this area. Throughout the Russian geological survey in the dam site, only two boreholes detected groundwater tables at the 91.5 and 120.5m depths. The nearest permanent river flow is the Kasakh River flowing about 5.2km west of the dam site forming a deep canyon, followed by the Hrazdan River flowing in a SW direction around 12km east, also forming a great canyon (see Figure 3-3.1, Guide Map). The water level of the Kasakh is 1,156m, and the groundwater levels found in the reservoir are 1,199m and 1,169m. The riverbed of the Hrazdan is approximately 1,150m. Based on these situations, a schematic hydro-geological cross-section was figured out as shown in Figure 3-3.2. As the figure indicates, the groundwater table shall be very flat, which means the permeability of the formations existing at the dam site is quite pervious.

During the D/D Study, water quality analyses on surface water were taken near around the dam site and groundwater samples were taken from the boreholes in the reservoir area where the groundwater table was detected (including a perched water) were carried out. Although the items of analysis were very rough, the results of these water quality analyses are shown in Table 3-3.3.

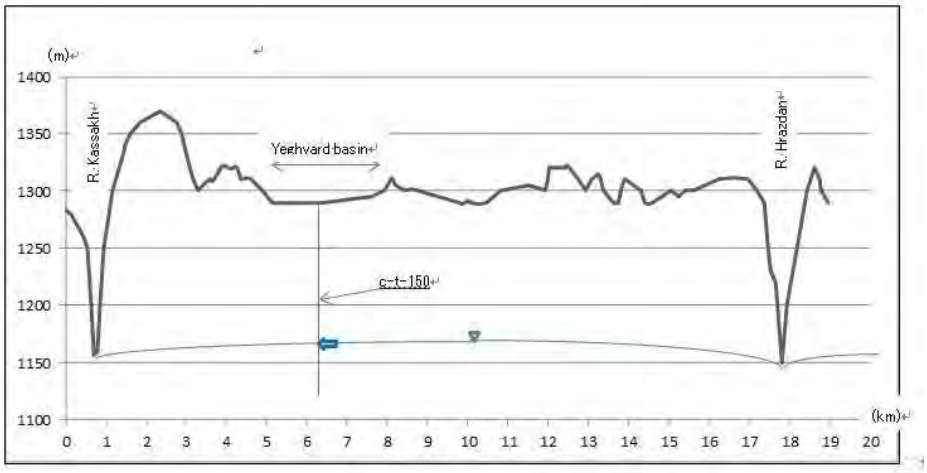


Figure 3-3.3 Schematic Hydrogeological Cross Section of the Yeghvard Area

Table 3-3.3 Results of Chemical Analysis on Surface and Groundwater

Table 3.3.3 Results of Chemical Analysis on Surface & Groundwater

1	3	4	5	6	7	8	10	11	12	13	31	32	34	35
			TDS	$Na^+ + K^+$	Ca^{++}	Mg^{++}	Cl^-	SO_4^{--}	HCO_3^-	CO_3^{--}	Hardness		Ph	CO_2
No.	Location	Depth (m)	(ppm)	(mg/lit)			(mg/lit)				(Total)	(Remov.)		(free)
1	Kassakh Spring	0	210.8	43.9	28	7.9	30.5	12	176.9	–	5.9	5.9	6.0	55.4
2	Borehole *N 101*	90.5	360.7	45.5	76	14	6.7	35.5	366.0	–	13.9	13.9	6.7	18
3	–Same above–	91.2	348.1	33.8	66	24.9	6.7	39.8	353.8	–	15	1.5	6.7	18
4	Arzni-Shamiran Can.	surface	524	102.6	40	42.6	106.4	46.1	306.0	–	5.5	5.5	7.6	n.m
5	–Same above–	–"–	544	20.9	50	94.8	70.9	72.8	396.5	36.0	10.3	5.6	8.2	–
6	Borehole *3464*	78.0 – 58.0	464	44.2	70.1	46.2	17.7	20.2	506.3	–	7.3	7.3	7.1	n.m
7	Borehole *3465*	83.0 – 80.5	367	41.4	60.7	29.2	35.5	38.3	329.4	–	5.4	5.4	7.6	11
8	Kassakh River	surface	374	8.5	40	64.4	70.9	37.0	298.9	–	7.3	4	7.2	6.6
9	Borehole *T-56*	25.1*	424.7	28.6	32.1	12.3	98.5	53.2	345.2	12.4	6.4	6.4	7.5	–
		*:Perched Water		EC=*x0.5										

4) Geology of dam foundation

The dam foundation of the proposed main dam (No.1 Dam) consists of, from upper to lower, a thin soft loamy sand cover, tuffs, sands of varying grain sizes, andesitic scoria, and basaltic andesitic lava

(refer to Figure 3-3.4 : Cross Section of Main Dam-axis). These layers are to be correlated with (1): $_{Vdp}Q_{IV}$ of top soil, (4): $_{\beta}Q_{III}$ (tuffs), (7): $_{lap\text{-}ap\text{-}lap}Q_{I\text{-}II}$ (sands), (12): $_{\beta}Q_{I}$ of pyroclastic flow, and (15): $_{\alpha+\beta}N_2$ (andesitic lava). Tuffs just under the top soil show 600-1,500 Ωm of apparent resistivity and the sands indicate low resistivity of 250-300Ωm, so that they are easily distinguished. Tuffs and andesitic lava are hard to very hard rocks but heavily cracked, and the sands are tightly bedded and consolidated or cemented by carbonate, but very porous. The planned No.2 dam site (sub-dam) is very long as around 2.5km length[1]. The foundation of the dam is represented by basaltic andesitic lava extending widely and horizontally throughout the long dam-axis. The northern half is, however, covered by a rather thick loamy sand layer correlated with Recent Sediments of (1): $_{Vdp}Q_{IV.}$ Below these, (4): tuffs, (7): diversely grained sands, (13): andesitic scoria, and (14): pebble-gravely sands with the total thickness in places ranging up to 40-50m bedded above the basaltic andesitic lava (15) at the practical bottom. The upper basaltic andesitic lava ($_{\beta}Q_{III}$ but lava portion) show very high apparent resistivity of 1,000 to 3,000Ωm. The underlying formations below the lava are correlated with$_{\beta}Q_{III}$ (tuffs), $_{lap\text{-}ap\text{-}lap}Q_{I\text{-}II}$ (sands), $_{\beta}N_2$ (andesitic scoria), $_{\alpha}N_2$ (pebble-gravely sands), and$_{\alpha+\beta}N_2$ (andesitic lava). The recent top cover ($_{Vdp}Q_{IV}$) is rather soft and loose. All other formations underlying are quite hard or densely compacted in the case of sediments, so that there is no problem for bearing capacity for the embankment. However, all of these layers are quite permeable because of heavy cracks or a heavily porous lithological property. It suggests heavy infiltration of water when the reservoir has been filled up by water.

5) Hydrogeology of reservoir area

During the geological investigation for D/D (1985), they carried out a total of 197 permeability tests, through injection to the boreholes and pouring to test pits. They revealed that the permeability of top soil ($_{Vdp}Q_{IV.}$) is about 2 x 10^{-4} cm/sec, but permeability of tuffs of late Pleistocene ($_{\beta}Q_{III}$) is 4.7 x 10^{-3}, scoria ($_{\beta}N_2$) is 9.8 x 10^{-3}, and pebble-gravely sands ($_{\alpha}N_2$) is 3.1 x 10^{-3} (cm/sec for all) as quite high values, and only middle Quaternary Sediments ($_{lap\text{-}ap\text{-}lap}Q_{I\text{-}II}$) shows a low permeability of 1.2 x 10^{-5} cm/sec. The report summarized the total average permeability of the foundation in the reservoir area which was as high as 4.67 x 10^{-3} cm/sec. Based on these permeability test results, they estimated a infiltration volume of reserved water, taking the water depth of the reservoir, and distribution, thickness, and depths of low permeability layers such as $_{lap\text{-}ap\text{-}lap}Q_{I\text{-}II}$ into account. As a result, they concluded that the infiltration amount of water from the reservoir shall be, at least, 8.32m^3/sec, and the volume can be converted to 262.4 MCM/year when the water depth is 27m (reservoir capacity is 90 MCM under their design). An infiltration amount of 262.4 MCM/year towards 90 MCM of reservoir volume means the reserved water shall be lost by infiltration within only 3.4 months. To realize the Project, quite reliable and practicable anti-infiltration measures are inevitably required.

[1] Measured on 1/50,000 topo-map.

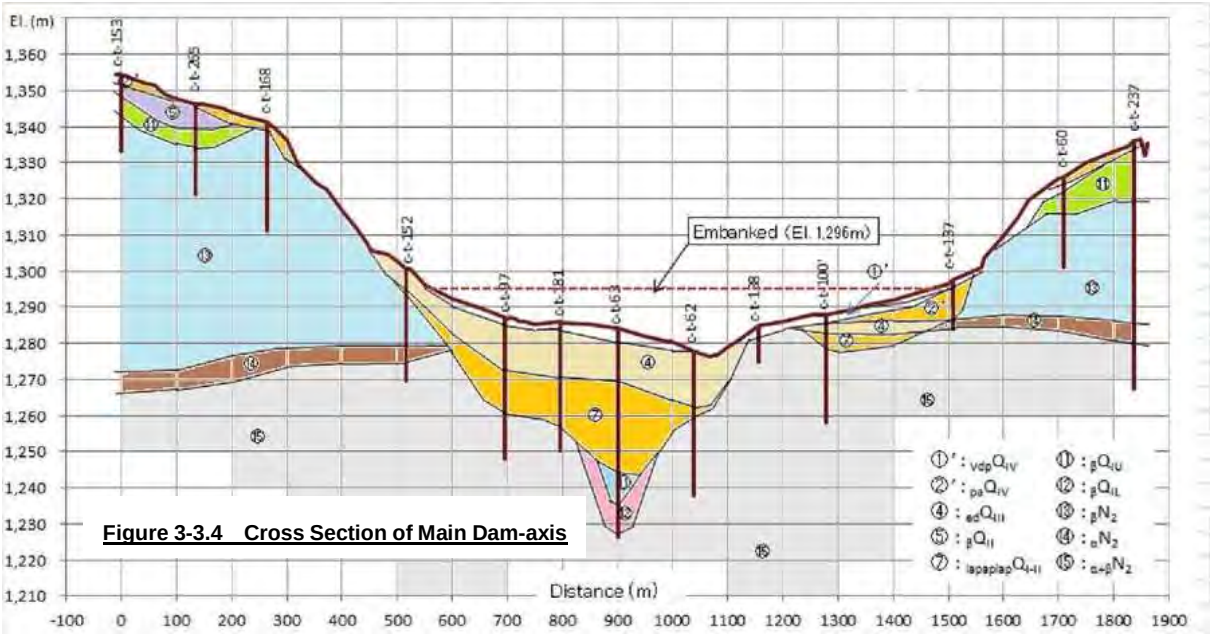


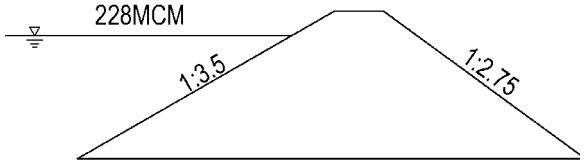
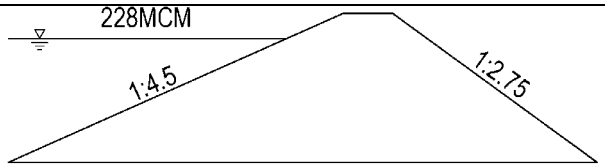
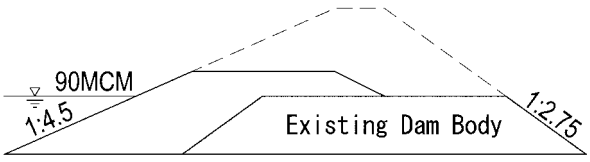
Figure 3-3.4 Cross Section of Main Dam-axis

3-3-2 Reservoir Construction Plan

1) History of the construction plan of the Yeghvard reservoir

The implementation of the Yeghvard reservoir started in 1984 after its construction plan was approved by Ministry of Agriculture and Ministry of Water Resources at the Soviet time. During the construction period the Spitak Earthquake occurred in 1988. This earthquake brought an opportunity to review the quake resistant design of the dam body (study was done in 1989). Construction was suspended in 1994 by reason of a financial problem of the Armenian Government after the independence from Soviet in 1990. In 1999, the capacity of the Yeghvard Reservoir was revised in consideration of the water resource circumstance in Lake Sevan and the balance between the irrigation development plan and the water supply capacity. Table 3-3.4 shows the summary of the changes/conditions in design during each period.

Table 3-3.4 Changes/Conditions in Design during Each Period

Year	Reservoir capacity (MCM)	Soil test	Stability analysis	outline	Sketch of the reservoir plan and the dam shape
1983	228	Done	Done	Original design	
1989	228	Done	Done	Review of quake resistance Upstream slope 1:3.5→1:4.5	
1999	90	- (Not done)	- (Not done)	Review of the reservoir capacity and the dam height (no touch to the details)	

2) Present reservoir plan

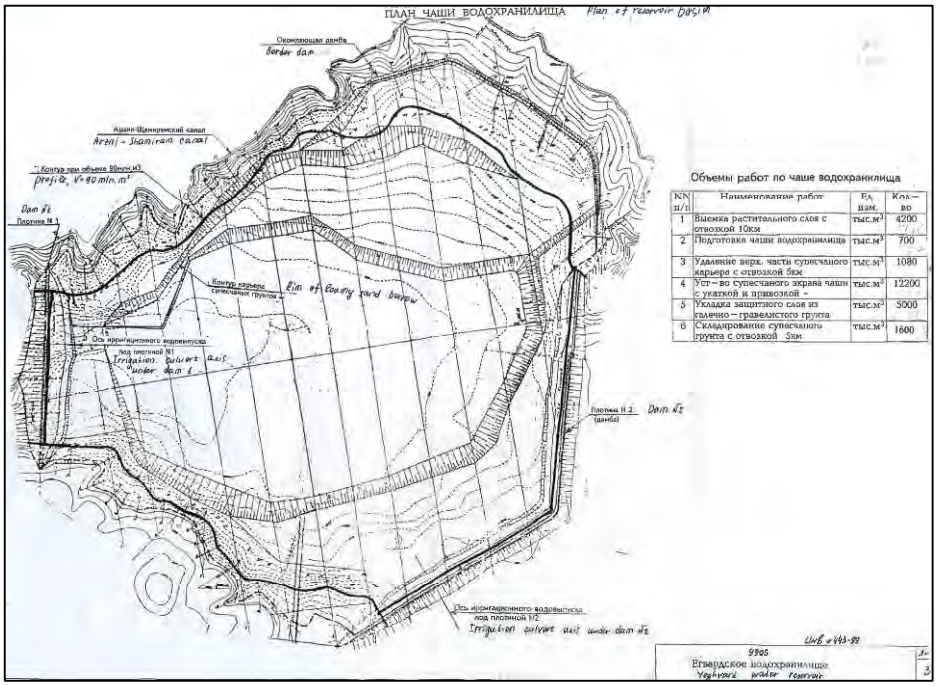
The contents of the reservoir plan revised in 1999 are shown in the Table 3-3.5, Table 3-3.6 and Figure 3-3.5.

Table 3-3.5 Present Reservoir Plan

Item	Unit	Size / Level
Total capacity of the reservoir	MCM	90.0
Available capacity of the reservoir	MCM	84.0
Full water level	m	EL. 1,304.5
Dead water level	m	EL. 1,284.5
Full water surface area	ha	825
Length of the reservoir	km	3.2
Useful water supply	MCM	80.8

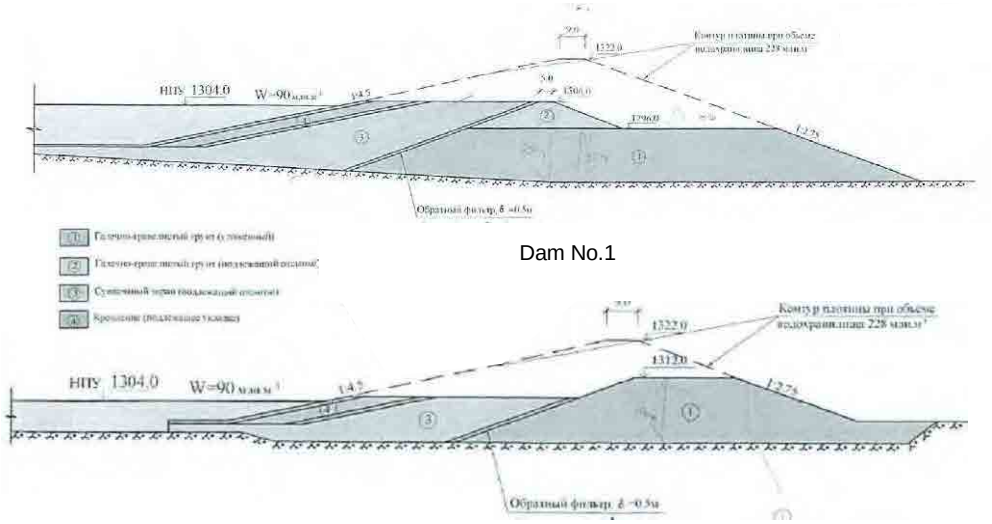
Table 3-3.6 Dam Type and Dimensions

Item	Unit	Dam No.1	Dam No.2
Dam type		Zoned fill dam with inclined impervious core	
Dam crest level	m	EL. 1306.0	EL. 1306.0
Maximum dam height	m	32.0	14.0
Dam crest length	M	1130.0	2810.0
Dam crest width	m	10.0	10.0
Upstream slope inclination		1 : 4.5	1: 4.5
Downstream slope inclination		1 : 2.75	1 : 2.75
Total embankment volume	MCM	1.86	2.10



Aerial view of the reservoir

Figure 3-3.5 (1) Reservoir Plan



Dam No.1

Dam No.2

Dam cross-section

Figure 3-3.5 (2) Reservoir Plan

3-3-3 Conditions of the Existing Embankments and Embankment Materials

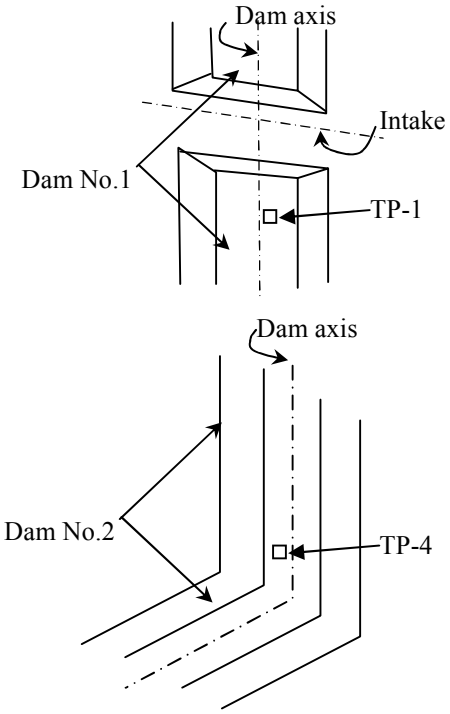
1) Existing embankments

Dam construction works started in 1984 and were suspended in 1994. The embankment filling works were carried out for only the sand-and-gravel zone, not for impervious core and other zones in both Dam No.1 and Dam No.2; and thus were built the existing embankments, Dam No.1 and Dam No.2. The materials of these embankments were obtained from a burrowed area which is situated on the northern gentle slope within the reservoir basin, and there are vacant lots with steep cut-slopes as shown in Figure 3-3.6.

Figure 3-3.6 Vacant Lots of the Borrow Area for Sand-and-Gravel Materials

a. In-situ investigations and tests (Test-pit excavation)

Test-pit excavations are conducted on the existing embankments, TP-1 on Dam No.1 and TP-4 on Dam No.2, to confirm actual material conditions. The depth of the test-pits is decided to be 1.5m considering the disappearance of a dried-up condition brought from the embankment surface. Test-pit conditions of each after excavation are shown as Figure 3-3.7.



TP-1 (on Dam No.1)

TP-4 (on Dam No.2)

Figure 3-3.7 Condition of Test-Pit Excavated on Existing Embankments

The following are the findings obtained through the investigations and tests.

i) Embankment materials

The embankments are composed of sand-and-gravel content which ranges from basaltic cobbles, maximum 400mm in diameter, to medium sand. Cobbles are hard and emit metallic sounds against the blow of an iron hammer.

ii) Compaction degree of the embankment

Large to medium sized rounded gravels consisting of the materials' main portion compose the framework of the embankment and sand fills the void of the framework. Sand lacking of small sized gravels and coarse sand look loose in density, but as a whole the framework structure looks robust and well-compacted.

iii) Compaction works to the embankment

The dim lines are observed every 40cm in depth on the test-pit walls, which are assumed to be the traces of the border between the compacted layers.

iv) Repose angle of sand-and-gravel materials

Repose angles were measured on the natural slope caused by the backhoe's dumping work of excavated materials. Five times of measuring resulted in 33°, 35°, 35°, 38° and 41°. In case of the slope being stamped by foot, the repose angle increases, so that the internal friction angle of $\varphi'=40°$ shall be applicable to the compacted condition of such materials.


(Repose angle measurement on the natural slopes of sand-and-gravel)

Note; The repose angle is defined as the internal friction angle of sand, sand-and-gravel and rock materials under the unconfined and loosest condition.

b. Laboratory tests

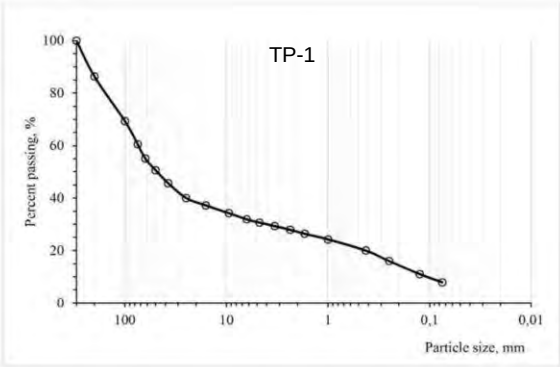
Laboratory tests are conducted on the samples obtained from the test-pits. The tests and their results are summarized as follows.

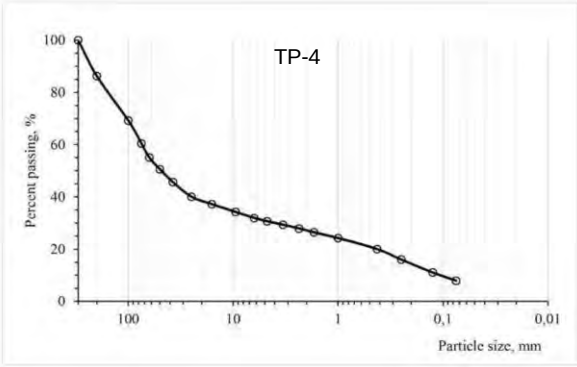
i) Field moisture content (Wf)

The field moisture contents of two samples from TP-1 and TP-4, which are the components less than 35.7 mm in grain size, are Wf=5.97% and Wf=7.04% that correspond to the moisture content condition in the dry side by about 7% from the optimum moisture content. Such moisture content conditions are the reflection of equilibrium in the field moisture content of sand or sand-and-gravel.

ii) Gradational condition

The sand-and-gravel materials are composed of the coarse portion larger than 20mm in grain size with 60% or more in content percent, the fine portion less than 1mm in grain size with 20% or more, and the medium portion 20mm to 1mm in grain size with about 15%.





iii) Rock quality

The value of water absorption is lower than 2% (TP-1; 1.87%, TP-4; 1.67%) so that the rocks in sand-and-gravels are regarded as fresh and not weathered.

iv) Compaction degree of the embankment

The field density of the content less than 37.5mm in grain size corresponds to about 98% of the maximum dry density in the laboratory compaction test conducted to the samples with the maximum grain size of 37.5mm. This density level is considered to be the reflection of well compacted condition of the embankment.

c. Conclusion

The quality of the existing embankments composed of sand-and-gravel is judged to be sufficient due to the following reasons, so that these embankments can be utilized as a part of dam body in the future reservoir plan.

- Firm framework structure of the embankment is composed of cobbles and gravels
- Enough and sufficient internal friction angle of sand-and-gravel materials are confirmed by the measurement of repose angles
- Enough gradational conditions, rock quality, compaction degree of the embankment, etc. are confirmed by the laboratory tests.

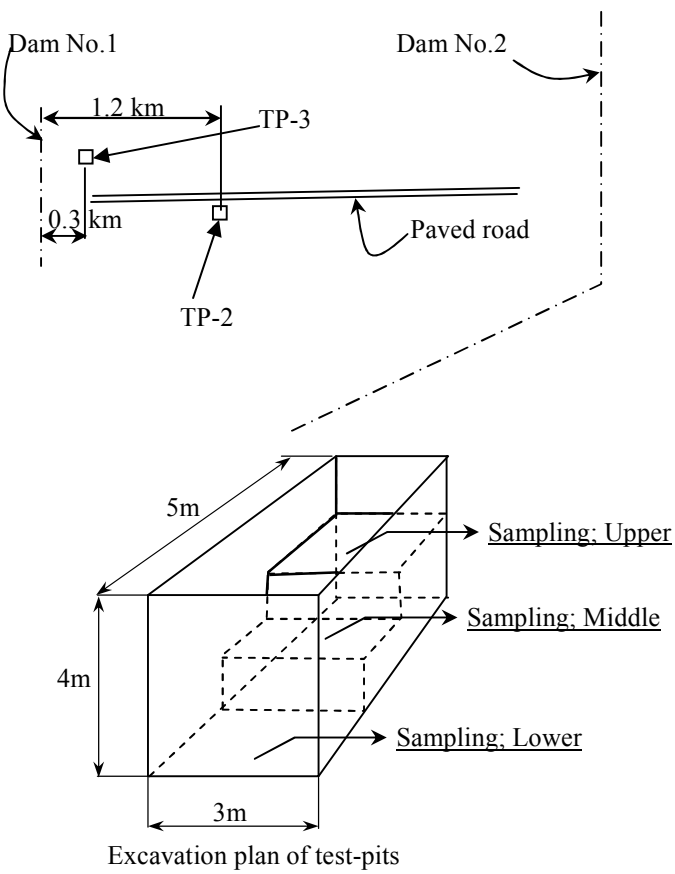
2) Embankment filling material for impervious zone

a. Test-pit excavation

Two test-pits, TP-2 and TP-3, are excavated within the area of the reservoir basin for the investigation of material for the impervious zone. Figure 3-3.8 shows the excavated shape of test-pits and the profiles after excavation. The following are the findings.

TP-2: The thickness of the top-soil is 30 cm to 40 cm; then follows the deposited soil till the test-pit bottom at 4m deep, which seems to be uniform in gradational conditions, is colored in light yellowish brown and is grasped as sandy clay with low plasticity. The grain size of sand tends to become coarse faintly in the upper portion and the moisture content increases a little from around 3m in depth; in other words the soil is dried-up till around 3m.

TP-3: The thickness of the sandy clay layer is thin (2m or so) including the top-soil layer. The deeper portion under this layer is composed of the deposited layer of rounded pumice and then non-plastic volcanic sand.




TP-2


TP-3

Figure 3-3.8 Profile of Test-Pit Excavation (Impervious Materials)

b. Laboratory tests

The laboratory tests are conducted to the samples obtained from the test-pits. The results are summarized as follows.

i) Field moisture content

The results are Upper: 10%, Middle: 14.05% and Lower: 15.27% in case of TP-2, and Upper: 9.43%, Middle: 6.07% and Lower: 8.33% in case of TP-3. The latter shows the influence of the pumice layer and the volcanic sand layer.

ii) Gradational condition

In the case of TP-2, the content percent of fine particles, i.e. clay and silt, is medium to high to be 32.14% to 86.52% and the gravels more than 4.76mm in grain size are scarcely contained. In the case of TP-3, the gradational conditions of the volcanic sand layer and the pumice layer are similar to sand-and-gravel.

iii) Specific gravity

In the case of TP-2, the value of specific gravity ranges from 2.55 to 2.61 which correspond to the one of the common soil. In the case of the volcanic sand in TP-3, the value is 2.71 which is not common and is assumed to contain some particular kind of mineral.

iv) Compaction property

The compaction property is one of cohesive soil with low plasticity showing a maximum dry density of 1.45 g/cm^3 (TP-2) and 1.55 g/cm^3 (TP-3), and an optimum moisture content of 24.0% (TP-2) and 21.1% (TP-3).

c. Conclusion

The sandy clay deposited thick in the low land area of the reservoir basin contains enough percentage of fine particles, i.e. clay and silt, so that this material is applicable to the core zone (anti-infiltration zone) of a inclined core type fill dam. However, any results or trace of laboratory permeability tests cannot be found in the existing reports in terms of soil tests so that it is necessary to carry out the laboratory permeability test to this material and bring out the material's permeability properties. In addition, the careful setting of the borrow area shall be needed because the edge of the area of target material has the possibility of containing some pervious materials such as pumice layers, volcanic sand layers or sand-and-gravel layers.

3-3-4 Cropping Plan

According to the F/S report in 1999, 7,500ha of farmland in the Nairi Community of the Kotayk Marz will be newly irrigated by the Project, and the F/S report contains a simple cropping plan of the area. On the other hand, the answers to JICA Questionnaire in July 2013 compiled by PIU says that about 12,200ha (the existing 9,220ha and the new 2,980ha) extending across 27 communities will be covered by the Project as described in "sub-chapter 3-2".

After a series of discussions with PIU during the Study, it is confirmed that the latter is the on-going plan of the Project. Since PIU is going to make a detailed cropping plan of the target irrigation area considering the cropping trend in and around the area, the JICA study team has offered PIU a possible cooperation to complete the plan.

3-3-5 Existing Irrigation Facilities

Currently, the existing Yeghvard Irrigation Development Project has its beneficiary of 9,220ha. Water

taken from the Hrazdan River is distributed through the Arzni-Shamiram canal into a beneficiary of 1,966ha in total, out of the total beneficiary of 9,220ha, consisting of 1,050ha under the beneficiary of the Yeghvard WUA and 916ha under that of the Ashtarak WUA. In addition, via the Lower Hrazdan canal, water is distributed to the beneficiary area equivalent to 7,254ha (consisting of the Varashapat WUA (605ha), the Khoy WUA (5,093ha) and the Aknalich WUA (1,556ha)). Figure 3-3.9 shows the irrigation system (see Appendix D-7). It also illustrates related facilities of the Yeghvard Irrigation Development Project.

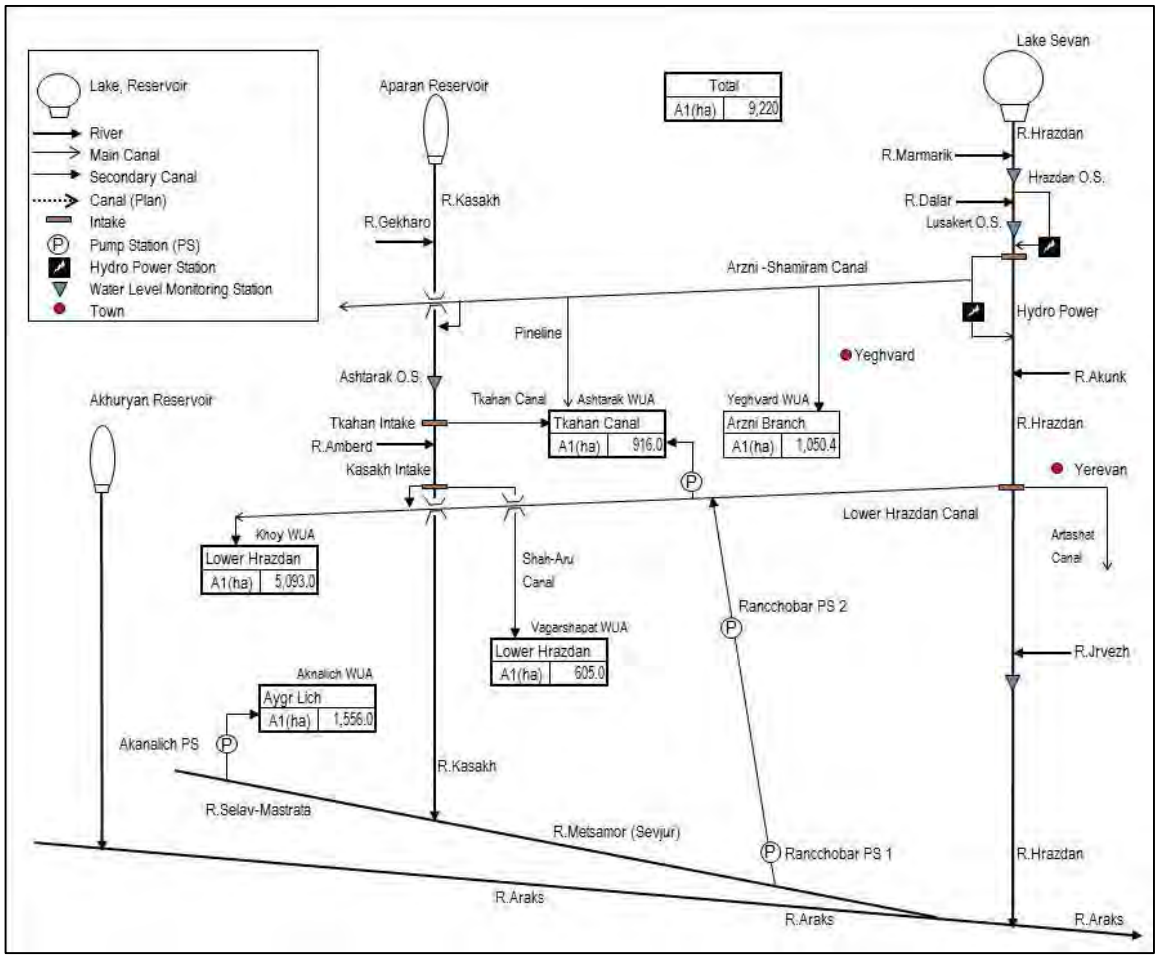


Figure 3-3.9 Diagram of Irrigation Network (existing)

1) Aparan reservoir

The Aparan reservoir is located at the upstream of the Kasakh River. It is administratively situated in the Aragatsotn Marz. It is a reservoir for irrigation, with a storage capacity of 90MCM. As shown in Figure 3-3.10, past performance shows that it actually stored water up to the nominal capacity of 90MCM in four years, 2006, 2007, 2010 and 2011, but the storage did not reach full storage level in other years. In particular, droughts hit in 2008 and 2011, during which the maximum water storage level was below 40MCM.

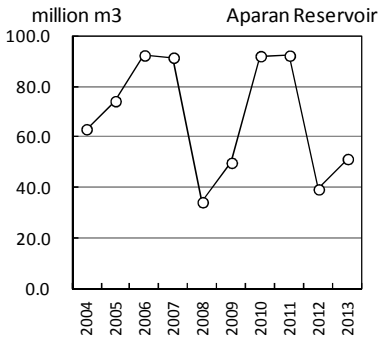


Figure 3-3.10 Change in Water Storage in Aparan Reservoir

2) Intake weirs

Four intake weirs are related to the beneficiary of the Yeghvard irrigation development project,

consisting of two (2) weirs in the Hrazdan River and the other two in the Kasakh River. There exist two weirs in the Hrazdan River, one of them guides water to the Arzni-Shamiram canal and another to the Lower Hrazdan canal. Intakes of the Lower Hrazdan canal has been worked as an intake for Artashat canal as well.

In the Kasakh River, two intake weirs are operated, one guide water to the Tkahan canal and another is the Kasakh intake that is used for the purpose of supplementing water into the Lower Hrazdan canal and also guide water to the Shah-Aru canal. The Kasakh intake was constructed during the 1950s, so the water injection gate used to add water to the Lower Hrazdan canal (installed at the right bank) and the gate of the Shah-Aru canal has already been fairly dilapidated. During irrigation season, water at the intake of Kasakh is guided to both right and left banks side. The radial gate at the central part of the intake weir is kept open in early spring with a view to prevent gates from damage by flood and canal from overflow spilling, so that flood water flowing from the upstream is released into the Kasakh River itself.

Arzni-Shamiram intake

Lower Hrazdan intake

Kasakh intake

Figure 3-3.11 Intake Weirs Installed at the Beneficiary of the Project

3) Pumps

In addition to two pump stations managed by WSA, many pump stations have been installed in the beneficiary area of the Yeghvard irrigation project that are managed by WUA. Figure 3-1.12 indicates changes in water volumes pumped up by Ranchpar pump station managed by WSA and those by the Aknalich pump station managed by WUA. Lifted water volumes by pumps show a decreasing tendency in both pump stations.

The Ranchpar pump station is located at the downstream of the Hrazdan River. It collects water flowing/accumulating into the lowland part of the Ararat Plain developed in the downstream of the beneficiary of the Yeghvard irrigation development project, then pumps it up into the Lower Hrazdan canal.

The Aknalich pump station depends on the water source of the Aknalich reservoir and has been operated by WUA. Water lifted up from the Akanalich pump station is distributed through two canals to a part of the beneficiary area of the Khoy WUA and the Aknalich WUA. Water volumes flowing into the Aknalich reservoir and intake site of Ranchpar have been decreasing in recent years. It is presumed that this tendency is attributable to a drawdown of the groundwater level over the Ararat Plain. The decrease entails in lowered water yield by pumps, thus disturbing the hitherto stable state of water intake.

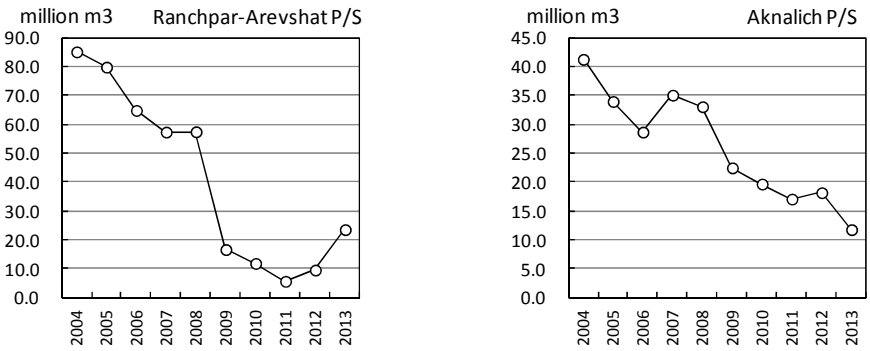


Figure 3-3.12 Changes in Water Volume Lifted by Pumps

Table 3-3.7 shows large- and medium- sized pump stations in the Yeghvard project area. Table 3-3.8 presents a record of operation costs of pump stations during the period 2008-2012 in the Rancchapar pump station that injects water into the Lower Hrazdan canal. Table 3-3.9 gives the electric charge for operating pumps. The record of water intake revealed that pumps were utilized more frequently in 2008 than usual. The average electric charge for pumping operation during the period 2009-2012 was 86,586,000 AMD (22,010,000 JPY) per year, and this is borne by the government subsidy.

Table 3-3.7 Pump Stations in the Beneficiary of Yeghvard Irrigation Project

Name of pump station	Managing agency
Ranchapar No.1	WSA
Ranchapar No.2	WSA
Akanalich	WUA
Metsamaro	WUA
Norakert No.1	WUA
Norakert No.2	WUA
Bagramyan No.1	WUA

Source: PIU

Table 3-3.8 Operation Cost of Rancchapar Pump Station

(thousand AMD/year)

	2008	2009	2010	2011	2012	Average
No1	225,878	107,915	78,092	45,363	68,777	105,205
No2	177,507	4,770	28,186	2,459	10,782	44,741
Total	403,385	112,685	106,278	47,822	79,559	149,946

source: WSA Average(2009-2012) 86,586

Table 3-3.9 Electricity for Rancchapar Pump Operated by WSA

(thousand kWh/year)

	2008	2009	2010	2011	2012	Average
No1	12,975	4,776	3,467	2,001	3,063	5,256
No2	12,075	235	1,426	125	549	2,882
Total	25,050	5,011	4,893	2,126	3,612	8,138

source: WSA Average(2009-2012) 3,910

Table 3-3.10 gives the number of small scale pump stations operated by the WUA and electricity charge of these stations (see Appendix D-8). It is confirmed from this table that the Khoy WUA, the Akanalich WUA and the Varagshapat WUA utilize groundwater over the Ararat Plain. According to WUAs, groundwater level has recently been drawn down, resulting in water volume yielded from each well. They say the cause of lowering the groundwater level is over-pumping by aqua-culture enterprises in the Ararat Plain. The following is the result of calculating the annual cost of electricity

for the operation of pump stations operated by WUA. The electric charge of pumps operated by WUA amounted to 325,460,000AMD (82,732,000 JPY), (in this case, 1AMD=0.2542 YEN).

It is clear that from the above discussed points the annual operation costs of pumps operated by the aforementioned WSA and by WUA are totaled to 412,046,000 AMD (104,742,000 JPY).

Table 3-3.10 Pump Stations Operated by WUA

Table Electricity for Pump Station operated by WUA

WUA	Tube Well (Number)	Pump Station (Number)	Electricity (thousand kWh/year)	Pump Station (Middle size) (Number)	Pump Station (Middle size) (thousand kWh/year)	Total Pump (Number)	Total Electricity (tousand kWh/year)
Yeghvard	0	0	0	0	0	0	0
Ashtarak	0	0	0	6	1,651	6	1,651
Vararshapat	22	0	1,287	0	0	22	1,287
Khyo	69	16	7,769	1	1,602	86	9,371
Akanalich	33	1	2,163	1	1,801	35	3,964
Total	124	17	11,219	8	5,054	149	16,273

source: PIU

Case 20AMD/kWh: Operation Cost (thousand AMD/Year) 325,460

Outlet from Ranshapar II pump station (WSA) Pump station located along main canal (WUA) A tube Well in crop field (WUA)

Figure 3-3.13 Pump Stations in the Project Area

Although the years of collected data are different, relative cost ratio is tried to be estimated based on the electricity output record for pumps operated by WSA and those by WUA. In the project area of the Yeghvard irrigation development project, water intake by pumps accounts for 19% in the case of those operated by WSA, while in the case of those operated by WUA it amounts to 81%. The size of pumps operated by WUA is in all cases smaller, but as many as 149 pumps are operated in the area. After the completion of the Yeghvard reservoir, it is planned that these pumps are abolished, whereby the government subsidy to pump operation is reduced and it can also contribute to the mitigation of heavy drawdown of groundwater level in Ararat Plain.

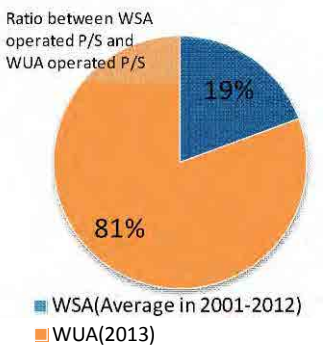


Figure 3-3.14 Water Intake Ratio between WSA's Pumps and WUA's Pumps

4) Main canal

As for the main canals, the Arzni-Shamiram canal and the Lower Hrazdan canal, the Kasakh River is considered as a border of the beneficiary, where the east side of the river is called Part I and its west side is called Part II. WSA is the responsible agency for the water supply to the main canal, gate operation and operation/maintenance of canals. Water runs only during the period of April-October, but later water is completely evacuated from the canal system and operation and maintenance works of canals are executed during the vacant season.

Rehabilitation work was implemented by the assistance of the WB for Part I of the Arzmi-Shamiram canal. The Government of Armenia considers additional rehabilitation for other parts one after another in addition to the above cited part of the rehabilitation assisted by the WB. However, due to a budgetary shortage, rehabilitation works by the government's own fund has not yet been realized. Figure 3-3.15 shows an example of a canal section constructed by the World Bank project. It is found that canal banks and the bottom part were rehabilitated by the project. However, check-gates, which make water intake easier by retaining the water level inside the canal, were not the targets of rehabilitation.

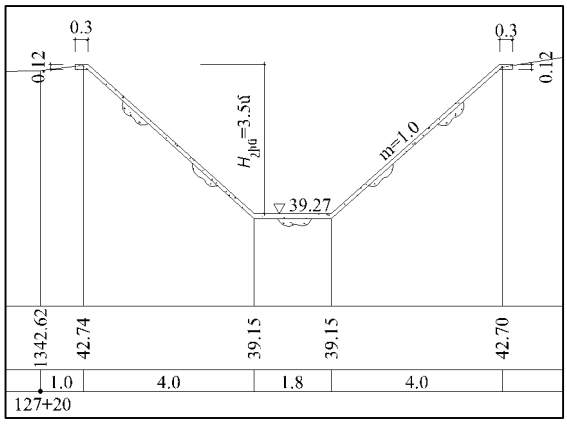
Arzni-Shamiram canal (before rehabilitation)

Arzni-Shamiram canal (after rehabilitation)

Arzni-Shamiram check gates (current state)

Figure 3-3.15 Main Canal and Check Gates

The section of the Arzni-Shamiram canal is designed to provide a flow of 28.2m^3/s at the starting point of Part I, while it is 15.0m^3/s at Part II after traversing the Kasakh River. The design section of the Lower Hrazdan canal provides a flow 10.0m^3/s at the starting point of Part I and 7.3m^3/s at Part II after traversing the Kasakh River. Water in each of these canals is divided and distributed into branch canals from division gates installed in the course of the main canals. The terminal discharge of the main canals is designed to provide a flow of 1.1m^3/s in the Arzni-Shamiram canal and 3.0m^3/s in the Lower Hrazdan canal. In this connection, the actual flow discharge is confined to about 80% of the designed values. Figure 3-3.16 is the section at the traversing point 127+20 in the Arzni-Shamiram canal, and PIU holds the cross-sectional data of the canal sections concerned.



Source: PIU

Figure 3-3.16 Cross section of Arzni-Sahmiram Canal

5) Canals and terminal parcels

Figure 3-3.17 shows a tertiary canal and a water inlet from it to field parcels. Two types of tertiary canals are observed; one type is rehabilitated into a concrete flume canal as shown in the left picture and the other is hitherto an earth canal in the center picture. Water conveyance efficiency of canals is as a matter of course higher for canals of the concrete flume type. The picture shown below in the right is an example of terminal parcels planted with cucumber after transplanting its seedlings. Furrow irrigation is commonly practiced as an irrigation method.

Tertiary canal (concrete flume)

Tertiary canal (earth canal)

A parcel under furrow irrigation (existing)

Figure 3-3.17 Canals and Parcels

As shown in the above pictures, a part of the secondary canals and most of tertiary ones have earth sections. Also, furrow irrigation is commonly practiced. As far as canals are concerned, water loss by infiltration loss from earth canals and intakes/inlets may become the cause of lowering water conveyance efficiency. In the parcels, furrow irrigation is practiced, by which parcels are irrigated from water inlet to parcel terminal along a furrow/ridge which may further augment irrigation water loss.

Table 3-3.11 shows the water conveyance efficiency in the irrigation system. The efficiency of the main canals has been improved by rehabilitation by WB. However, as to efficiency ranging from secondary canals to the terminal parcels, the efficiency is degraded to 60%-70% because they are mostly earth canals. Under such a current status, water conveyance efficiency of the Yeghvard irrigation development project remains as low as 51%-55%.

Table 3-3.11 Water Conveyance Efficiency of Canals in the Yeghvard Irrigation Development Project

Related facilities	W.C.E. (%)	Observed agency
Main canal	85%	WSA（Water Supply Agency）
Secondary～Tertiary～Parcels	60～65%	WUA（Water Users Association）
The entire value (main canal ~ parcels)	In total: 51%～55%	-

Source: PIU

6) Present state of water distribution from Lake Sevan

Table 3-3.12 gives the present state of water distribution to the Arzmi-shamiram canal including the existing beneficiary area and the Lower Hrazdan canal (as a monthly mean during 2005-2013). As shown in this table, 108MCM is distributed to the Arzni-shamiram canal, 83MCM is to the Lower Hrazdan and 26MCM by pumps at Ranchpar.

Table 3-3.12 Distribution Channels to the Existing Irrigation Facilities

(MCM)

Distribution facility	4	5	6	7	8	9	10	11	Total	Remarks (July~November)
Arzni-Shamiram	2.3	20.4	18.5	23.2	26.3	13.4	2.3	1.1	108	66
Lower Hrazdan	4.0	13.0	17.5	16.7	15.4	10.4	4.0	1.9	83	48
Ranchpar P/S	0.8	2.6	5.8	5.3	5.8	4.8	0.7	0.1	26	17
Total	7.1	36.0	41.8	45.2	47.5	28.6	7.0	3.1	217	-

Source: Water Supply Agency

How much volume of irrigation water is distributed through the existing irrigation facilities (9,220ha) from Lake Sevan is roughly estimated here. Generally, the runoff-discharge level flowing from the watershed area of the Hrazdan River is high during the period of April-June. This based on the

assumption that irrigation water used in this period is all supplied from the Hrazdan River whereas irrigation water supplied in July or later originates both from the Hrazdan River and Lake Sevan.

According to data of the water distribution program by WSA, the ratio of water volume that is supplied for irrigation between the watershed of the Hrazdan River and that of Lake Sevan is 30%: 70% on average. Likewise, assuming that the ratio of design section of two canals, the Azrni-shamiram and the Lower Hrazdan, is equal to the ration of water volume distributed to Part I and Part II, in consideration with the above-mentioned relationship between the design sections of irrigation canal and conveyed water volume, the rate of beneficiary coverage of the Yeghvard irrigation project (9,220ha) by each of these canals is as follows:

Table 3-3.13 Rate of Irrigation Area Coverage for Part I and Part II by Two Canals

Related facilities	Part I	Part II
Arzni-Shamiram Canal	50% (target area of the project)	50%
Lower Hrazdan Canal	30%	70% (target area of the project)

Judging from the above assumption, the mean water volume supplied from Lake Sevan to the beneficiary area of the Yeghvard irrigation area (9,220ha) can be estimated at about 50MCM.

Through Arzni-shamiram Canal: 66MCM x 70% x 50% = 23MCM
Through Lower Hrazdan Canal: 48MCM x 70% x 70% = 24MCM
Total 47MCM (= about 50MCM)

3-3-6 Current Irrigation Plan

The current irrigation plan targets a beneficiary of 12,200ha, in addition to the existing beneficiary of 9,220ha, it is planned to add a new beneficiary equivalent to 2,980ha. Presently, around 100 million yen/year is incurred as an annual pump operation cost to irrigate 9,220ha. Thus, the concept of the Yeghvard irrigation development project lies in introducing the gravitation type irrigation method by constructing the Yeghvard reservoir, thereby economizing pump operation expenses.

The newly added 2,980ha is not at all a brand new reclaimed area. This area is located adjacent to an already irrigated beneficiary area nearby secondary canal, but has long been suffering from failure of receiving the irrigation benefit because canal water has been too scarce to cover it. Therefore, once the Yeghvard reservoir is completed, it can secure water required to irrigate the newly added beneficiary area, thus becoming immediately irrigable. In addition, these area needs construction of tertiary canals from the secondary canal, and it is desirable that these activities should be carried out by WUA.

In order to avert a detrimental effect of excessive water intake to Lake Sevan, water conveyance to the Yeghvard reservoir utilizes the flowing discharge in the Hrazdan River during the season of a higher level of discharge coincided with the thawing period in early spring. Water taken from the Hrazdan River is conveyed to and stored into the reservoir by means of the existing canals. In doing so, it is envisaged that heavy dependence on Lake Sevan could be mitigated, at the same time reducing dependence on groundwater deposited on the Ararat Plain. After the construction of the Yeghvard reservoir, it is planned that too heavy dependence on groundwater lifting pumps including not only those operated by WSA but also those managed by WUA is nullified and most of the required water is solely distributed by gravity irrigation.

CHAPTER 4 ISSUES AND DIRECTION ON THE YEGHVARD IRRIGATION DEVELOPMENT PROJECT

4-1 Conformity with Related Plans/Policies

4-1-1 National Development Policies

Though ADS (2014-2024: Armenian Development Strategy) does not describe much as to the irrigation sector, it mentions to invest funds equivalent to 0.3% of the GDP (equal to around 30 million USD) for new development of this sector and also to strive for maintenance/development of the existing irrigation system by additional budgetary appropriation. Also, regarding the conservation and utilization of water resources, the Law on Fundamental Provisions of the National Water Policy formulated in 2005, has placed the top-most priority on water conservation for the nation in its provision of political priority order (Article 13), further giving a relative superiority ranking of resource usage in the following order: 1) tradition/custom, 2) international laws, 3) what is essential for the nation, 4) agriculture (irrigation/livestock/non-industrial activities), 5) energy, 6) industry, 7) recreation, and 8) measures during drought periods. It is interpreted that this Law gives a superior priority on irrigated agriculture among several economic activities by conserving Lake Sevan, which has been serving as a lifeline/foundation for the nation in both the sectors of livelihood and industrial activities. In light of the current critical states of major lakes in neighboring areas such as the Aral Sea which has been exposed under threat of extinction and Lake Ormie in the Azerbaijan province of Iran, the surface area of which has sharply been diminishing, the statement in this Law gives particular importance to the conserving of Lake Sevan for the Armenian nation with the fact that policy measures have been taken for this purpose since the 1980s, including water injection by trans-watershed diversion and a discharge limitation of 170MCM/year.

Founded on the Law on Fundamental Provisions of the National Water Policy, the National Water Program was formulated in 2006. Article 19 of this Law, stipulating tasks and the prospect of developing an irrigation sector, the following measures to tackle them have been listed: 1) promoting a subsidized assistance policy for the WUA, 2) shifting the irrigation system from pump to gravity (saving O/M cost), 3) consolidating irrigation infrastructure and introducing modern irrigation techniques; 4) Improving O/M efficiency by means of rehabilitating irrigation system, 5) initiating participatory water management by the WUA, 6) Expanding the irrigated farmland area; and 7) improving the code of irrigation criteria, etc. Furthermore, this Program underlines the sustainable promotion of the above-cited measures that requires stable security of availing water resources, thus water storage facilities should be consolidated for meeting this requirement.

4-1-2 Agricultural Development Plan

This Project aims at increasing crop production in the target area of 12,200ha by improving the irrigation condition in the area. The consistency between the Project and SADS, especially the expected impact of the Project to the 8 parts of SADS's vision, is arranged in Table 4-1.1.

Table 4-1.1 Influence of the Yeghvard Irrigation Project to the Vision of SADS

No	Vision of SADS	Direct influence	To be considered in the actual implementation	Indirect influence
1	Enhancement of sustainability and competitiveness of agriculture	X		
2	Organized, highly competitive and market-oriented production with horizontal links with the other economy sectors		X	
3	Sustainable provision of food to the population and meeting the demands of the processing industry	X		
4	Increase in gross farm produce will be ensured by increased labor productivity			X
5	Considerable part of the produced agricultural low materials will be processes by the SME in rural communities			X
6	Positive change in the intrasectoral structure of plant and livestock production		X	
7	Utilization of the agricultural potential and especially land resources will improve considerably	X		
8	Food security level of the population of the country will rise		X	

Source: The JICA Study Team

As shown in the above table, there are parts of SADS's vision which have a direct relation to the Project (No.1, No.3 and No.7), while there are other parts of SADS's vision which shall be given attention during the actual implementation of the Project (No.2, No.6 and No.8). In addition, there are parts of SADS's vision which shall be covered by the national or regional agricultural policies, not only by the Project (No.4 and No.5).

4-1-3 Project Plans by Other Donors

Presently, the Government of Armenia requests assistance under reimbursable fund cooperation with Germany (KfW), France (AFD) and Japan (JICA) for implementing three (3) projects out of nine (9) projects that had been planned during the era of the Soviet Regime and for which detailed designs were completed, but the construction was suspended before completion. Out of these, the Kaps project under the assistance of Germany and the Vedi project assisted by France are now in the final stage of the F/S study. Table 4-1.2 compares the outlines of these three (3) projects.

Table 4-1.2 Comparison of the Outlines of 3 Projects

Project	Dam /Reservoir			Agriculture		Irrigation		Project cost Million Euro (Million USD)
	Dam height (m)	Volume (MCM)	Reservoir surface area (000m2)	Planned main crop (Major→ Minor)	Planned water demand (MCM/y) (Saving irrigation %)	Existing irrigation area (ha)	Planned irrigation area (ha)	
Kaps (KfW)	55m	25MCM	Approx. 1,300	1)Wheat 2)Barley 3)Potato 4)Maize 5)Vegetable	Approx. 25MCM (Saving irrigation: S.I.100%)	2,148ha	19,240ha	82.5M.Euro (103M.USD)
Vedi (AFD)	72.5m	29MCM	Approx. 1,400	1)Vegetable 2)Fruit, 3)Grape, 4)Wheat, 5)Fodder	32MCM (S.I. 50%)	2,440ha	2,820ha	90M.Euro (113M.USD)
Yeghvard (JICA)	30-35m	90-110 MCM	Approx. 8,400	1)Wheat, 2)Vegetable 3)Grape, 4)Fruit, 5)Fodder	148MCM (S.I. 0%)	9,200ha	12,200ha	-

Source: Kaps, Vedi F/S Report

Both of these, the Kaps and Vedi projects, as project benefits, they propose increased crop/livestock benefits by the expansion of the irrigated perimeter and improved irrigation systems, and also both of these envisage conversion from current beneficiaries irrigated by pumps into planned ones by gravity, thus greatly saving O/M costs for these projects. In particular, in the Kaps project, collapse of the dam is assumed as a risk, assuming that a drainage tunnel to downstream which was constructed under the Soviet regime but is now heavily dilapidated is choked, thus the project has been considered top-ranked in Armenia. In this connection, the introduction of water-saving irrigation is applied to all the irrigation projects because of the limitation on required water for irrigation to observe the discharging duty to the Akhuryan reservoir that has jointly been operated with Turkey. On the other hand, as for the Vedi project, it reiterates the reduction of O/M costs by partly abolishing the existing pump stations along the Araks River, a trans-border stream, thus making the project acceptable to Armenia in compliance with the irrigation policy of Armenia.

4-1-4 Feasibility of Constructing the Yeghvard Reservoir

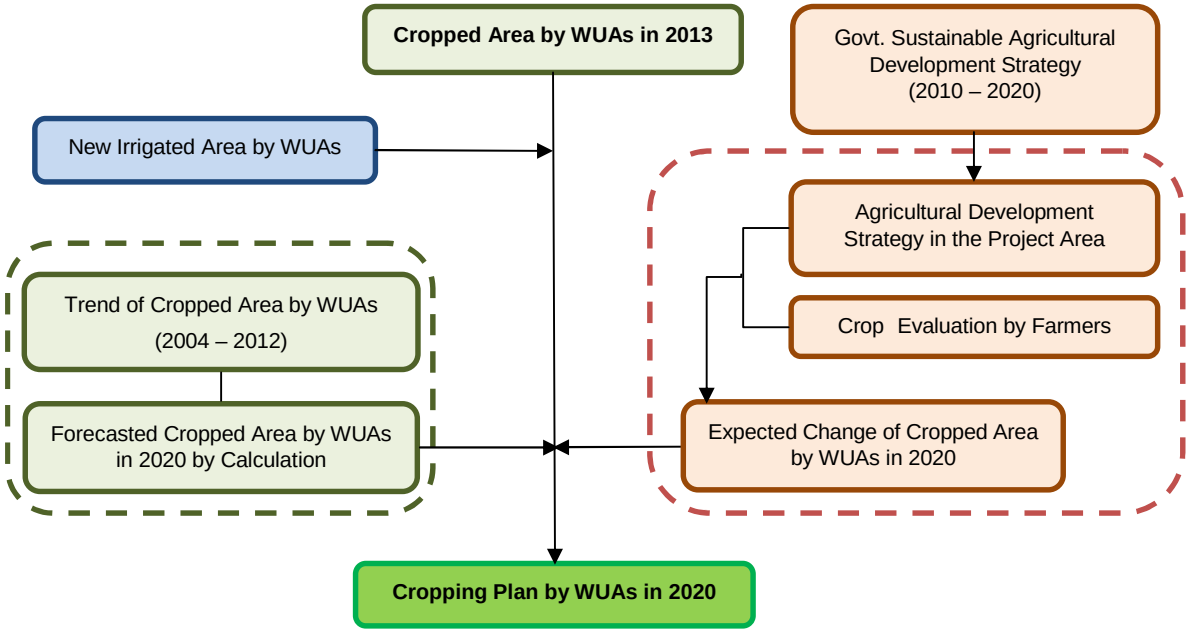
Though it is necessary to wait until an authentic F/S study is carried out for calculating project cost and IRR of the Yeghvard irrigation project in comparing the Yeghvard irrigation project with the above-mentioned Kaps and Vedi projects, no significant difference is considered to arise from crop/ livestock benefits so far as there is no outstanding difference in major farming characteristics or planned crops among these three projects. The IRR of Kaps is conceived to have a high level because it assumes the benefit of averting the risk of dam collapse. The Yeghvard reservoir has a larger water storage area (water surface area) than those of the reservoirs in the other two projects, thus escalation of the project cost is anticipated depending on the type of work adopted for securing sustainable water shielding. On the other hand, about 50MCM/year of water currently relying on lake Sevan (equivalent to about 30% of the limit of discharge from the lake, 170MCM/year) can be saved by constructing this reservoir. Depending on how to calculate the benefit of this project, a high possibility is expected to make the project feasible/acceptable.

4-2 Project Agenda

4-2-1 Cropping Plan

A concrete cropping plan of the target irrigation area after completion of the reservoir by the Project was not examined when the Study was commenced. The cropping plan should be completed first before examining the feasibility of the Project. Under the present free economy system, a cropping plan of individual farmers shall be decided by their own interests. It is, however, important that the Government presents a tangible direction of agricultural development to concerned farmers and other stakeholders in the target area based on SADS and the present agricultural condition of the area.

The following description shows that a logical structure of cropping planning in the target area and the outcome based on the collected information from the Study. The planning procedure is shown in Figure 4-2.1.



Source: The JICA Study Team

Figure 4-2.1 Cropping Planning Procedure

1) New irrigated area

About 2,980 ha of farmland will be newly irrigated by the Project. Since it is impossible to grow crops without irrigation in the area, no crop is grown in the 2,980 ha of farmland. After the Project, crops will be newly grown in all the farmland area. Table 4-2.1 shows the new irrigated farmland area by concerned WUAs.

Table 4-2.1 New Irrigated Area by WUAs

WUA	New Irrigated Area (ha)	(%)
Yeghvard	1,377.3	46.2
Ashtarak	823.9	27.6
Vagarshaat	34.3	1.2
Khoy	143.9	4.8
Aknalich	601.8	20.2
Total	2,981.2	100.0

Source: PIU, State Committee of Water Economy

It should be noted that more than 2,000 ha, about 73.8% of the new irrigated farmland is included in command areas in the Yeghvard WUA and the Ashratak WUA. Both WUAs' command areas border on the northern edge of the Ararat Plain, and mainly consist of gentle slopes transitioning to mountainous terrains. Fruits, including grape, and alfalfa are grown more than cereals and vegetables at present, and also SADS prioritizes fruit farming and the raising of livestock in the area.

2) Forecasted cropped area based on the trend

The ratio of cropped area by major crops in 12,200ha of the target irrigation area in 2020 is forecasted by the calculation based on the actual cropped area of major crops during 2004-2012 in the concerned five (5) WUAs. In concrete terms, a logarithmic curve formula is formulated from the actual cropped area for each crop in every WUA. Then, the ration of cropped area is derived from the calculation. The cropped area of 12,200ha is finally calculated to apply the ratio. Table 4-2.2 shows the calculation result and accrual cropping ratio of major crops in the target area (9,220 ha) in 2013 for comparison.

Table 4-2.2 Calculated Cropped Area in 2020 in the Project Area

Crop	Cropped Area		
	2013 (%)	2020 (%)	2020 (ha)
Wheat	22.0	26.5	3,235.0
Vegetables	22.9	21.4	2,609.3
Grape	14.8	15.1	1,847.0
Orchard	10.7	14.2	1,734.3
Perennial grass	9.1	12.2	1,488.4
Other	20.6	10.0	1,286.8
Total	100.0	100.0	12,200.8

Source: The JICA Study Team

3) Agricultural development strategy in the project area

While SADS shows the agricultural development strategy by Marzes (see Table 2.3.3), the following Table 4-2.3 shows the suggested strategy for the target irrigation area (12,200ha) considering the present agricultural situation.

Table 4-2.3 Suggested Agricultural Development Strategy in the Project Area

Sub-sector	Suggested Strategy
Cereals	● To increase productivity ● To promote forage cereals (barley, maize, etc.)
Vegetables	● To promote autumn/winter production by greenhouses (continuous harvesting throughout the year) ● To diversify crops (new crops including new varieties and ornamental plants) ● To promote hygiene-oriented processing industry
Fruits/Grapes	● To increase planted area and productivity ● To introduce long-term storage technology/system ● To promote hygiene-oriented processing industry
Forage crops	● To increase cropped area
Livestock	● To increase the number of cattle (meat and dairy) ● To promote poultry farming & pig/sheep breeding ● To promote hygiene-oriented processing industry

Source: The JICA Study Team

4) Crop evaluation by farmers

As descried, farmers decide their cropping plan by themselves and they grow crops in accordance with the plan. The cropping plan is influenced by the farmers' intentions to grow crops. Table 4-2.4 shows advantages and disadvantages of crops evaluated by farmers in the target area.

Table 4-2.4 Crop Evaluation by Farmers

Crop	Advantages	Disadvantages
Wheat	● Can secure bread (still important for livelihood) ● Easy crop (less costs, easy management and stable yield) = Suitable to large scaled production ● Government's support for seeds	● Low selling price, not profitable much
Vegetables	● Profitability per ha is high ● Can expect short-cycle return ● Ararat plain is suitable for growing vegetables (can grow 2 times or more in a year)	● Unstable price (very low price in peak harvesting season) ● Left over in peak harvesting season (no buyers) ● Risky crop (high costs and many diseases & insects) = Difficult to expand cropped area
Grape & Fruits	● Profitability per ha is relatively high ● Easy management = Suitable to large scaled production ● Processing factories (buyers) of grape are close	● Need long time to get harvest (cannot expect short return) ● Cannot change crops in short period (not flexible) ● Yield is not stable (susceptible to a natural disaster)
Alfalfa (Perennial grass)	● Good for crop rotation (improve soil fertility) ● An important forage source	● Not profitable, if not combined with livestock (less cattle in Ararat plain)

Source: The JICA Study Team

5) Expected change of cropped area

Considering the Agricultural Development Strategy in the Project Area, the Crop Evaluation by Farmers and SADS by Marzes in total, a change of cropped area in the target area in 2020 is expected as shown in Table 4-2.5.

Table 4-2.5 Expected Change of Cropped Area by WUAs in 2020

WUA	Expected Cropped Area Change in ha (comparison with the area in 2013)						
	Wheat	Vegetables	Grape	Orchard	Perennial grass	Other	Total
Yeghvard	High increase	Increase	High increase	High increase	High increase	High increase	Very high increase
Ashtarak	Increase	Stable	High increase	High increase	High increase	High increase	High increase
Vagarshapat	Stable	Stable	Increase	Increase	Stable	Stable	Stable
Khoy	Stable	Stable	Increase	Stable	Stable	Increase	Slightly increase
Aknalich	Slightly increase	Increase	Increase	Stable	Increase	Increase	High increase
Total	High increase	Slightly increase	High increase	High increase	High increase	High increase	High increase

Source: The JICA Study Team

6) Suggested cropping plan in 2020 (draft)

A suggested cropping plan in the target area in 2020, as shown in Table 4-2.6, is finally made based on Table 2-3.3, Table 3-2.1, Table 4-2.2, Table 4-2.3, Table 4-2.4 and Table 4-2.5.

Table 4-2.6 Suggested Cropping Plan in 2020 (draft)

WUA	Cropped Area (ha)						
	Wheat	Vegetables	Grape	Orchard	Perennial grass	Other (potato, barley, maize, etc.)	Total
Yeghvard	500	100	250	650	480	448	2,428
Ashtarak	140	80	550	300	210	459	1,739
Vagarshapat	295	165	40	55	25	59	639
Khoy	1,300	1,200	850	550	350	986	5,236
Aknalich	500	700	120	25	275	538	2,158
Total (%)	2,735 (22.4)	2,245 (18.4)	1,810 (14.8)	1,580 (13.0)	1,340 (11.0)	2,490 (20.4)	12,200 (100.0)

Source: The JICA Study Team

4-2-2 Promoting Export-oriented Farm Products

SADS aims at improving the national food security level and promoting export-oriented production through increasing total productivity of the national agriculture and balanced distribution of the products to the domestic and the international markets. The target irrigation area is located in a part of major vegetables and fruits production center in Armenia. However, farmers in the area have difficulty marketing their products, even seasonally, due to saturation of the domestic market after the increased production in recent years. Vegetables and fruits, including the processed products, are Armenian's traditional exporting commodities, as well as it is very important to promote the export for the agricultural development in the area. As described in "sub-chapter 2-3-9", there are many problems for promoting the export at present. Table 4-2.7 shows the SWOT analysis of the export of Armenian Agricultural Products in order to understand the present situation and circumstances.

Table 4-2.7 SWOT Analysis of the Export of Armenian Agricultural Products

Internal Environment Factors	
Strengths	Weaknesses
● Blessed annual sunshine hours ● Hard working skilled farmers ● High production of fruits (including grape) and vegetables (have a capacity to export) ● Established leading production regions for fruits & vegetables (good base to develop an efficient value-chain/clusters)	● Limited farmland (hilly & mountainous landscape) ● Cold winter and low precipitation ● Concentrated harvesting-time of major crops (need continuous export marketing throughout the year) ● Meat production is far less than the domestic demand (Except sheep/goats) ● High production costs (inputs & labors) ● Export tax ● Low-functioning quality control and inspection system (standards, pesticide restriction/residue, hygiene control, etc.) ● Inefficient marketing networks ● Limited investment to agro-industries (logistics and processing)
External Environment Factors	
Opportunities	Threats
● Long history of export to CIS countries ● Good reputation of quality fruits & vegetables and brandy in CIS countries ● Exporting live sheep to Iran ● Big potential markets (Russia and Europe) are close ● Networks of Armenian Diaspora	● Many strong competitors (e.g. Turkey, Uzbekistan, Iran, etc.) in CIS countries ● Different taste of European markets from CIS markets (need a new challenge) ● High quality standards (appearance, grading, quarantine, etc.), and reliable & stable marketing volume required for European markets ● Strict requirements for safety and security (hygiene) of foods in European markets (impossible to export without a certificate from a reliable authority) ● Limited exporting routes (actually only a road transportation through Georgia) ● Unstable socio-economic situation of the largest market, Russia

Source: The JICA Study Team

The following strategy for promoting the export may be drawn after analyzing the SWOT.

1) Target markets

Diversification of the markets;

- Short term: Russia & other CIS countries (keep and expand the present markets)
- Mid-long term: EU countries (develop new markets)
  Need to promote hygiene-oriented (safety & security) products

2) Target crops/products

- Vegetables
- Fruits & Grape, including Brandy and Wine
- Flowers & Ornament plants (Mid-long term)
- Sheep (Live animals to Iran)
- Meat products (Mid-long term)
  Need to fulfill domestic demand for the short term

3) Agribusiness development

- Clod chain system (transportation & storage)
- Hygiene-oriented processing (Mid-long term)
  Need to target domestic market for the short term. Armenia is exporting processed foods to mainly CIS countries, while importing more than the exported amount from non-CIS countries, may be hygiene-oriented products, at present.

4-2-3 Directives of Water Resource Use in Lake Sevan

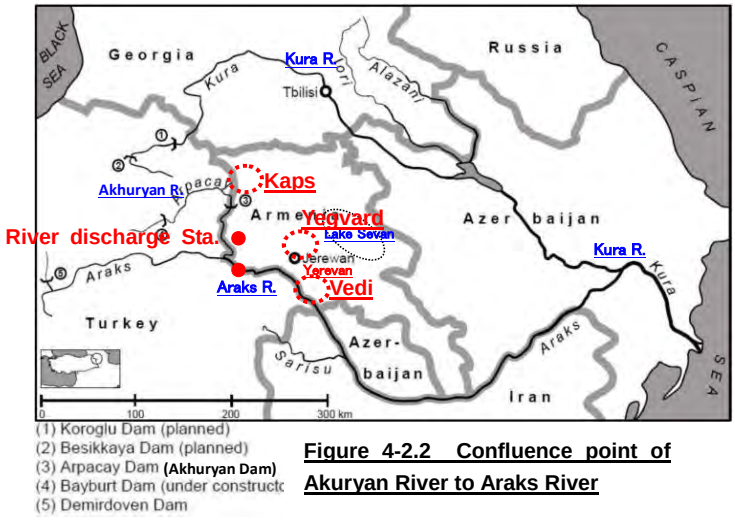
Lake Sevan is indeed a precious water resource for Armenia with multi-facet objectives including irrigation, hydropower generation, environment/ recreation etc. Discharge volume from Lake Sevan to the Hrazdan River has completely been under control. Water is not released from Lake Sevan to the Hrazdan River except during irrigation period. In Armenia, priority has been placed on irrigation rather than on hydropower generation.

It is predicted that in the future, rising atmospheric temperature, decrease of rainfall, and augmentation of crops' water requirement associated with such temperature change are induced by climatic change. Around the Hrazdan River that is located near the Capital Yerevan, in association with such environmental change as mentioned above, demographic growth and escalated water demand for industrial and urban domestic water use are anticipated, thus critical scarcity of water resources is considered as a growing concern.

Under such a background circumstances, top priority issues to be tackled include restoration of water level in Lake Sevan, rights management of water resources not exceeding 170MCM per annum, construction of reservoirs, etc. As to the level of 170MCM per annum, though it does not restrain water release from the lake to downstream in such occasions as drought years with scarce annual rainfall, water management for alleviating a burden on Lake Sevan as much as possible is still an important theme to be addressed. In identifying the real state of watershed situations other than those of Lake Sevan, it becomes imperative to stand on the concept of managing plural watershed areas in a comprehensive/coordinated way.

4-2-4 Consideration for Trans-boundary Streams

Considering the preceding two projects, Kaps provides its plans in conformity with a duty of the Armenian side to release/discharge 150MCM/year to the Akhuryan reservoir that has been co-managed with the Turkish side. With this concern, according to the report of TIWRM (by WB), discharge observation data collected from the observatory located at the upstream side and from another at the downstream side of the confluence point of the Akhuryan River with the Araks River as shown in Figure 4-2.2 show a different tendency, namely, discharge in the upstream tends to increase but that in downstream tends to decrease. This implies that water development on the Turkish side is more outstanding, and if any decline in discharge in the downstream of the Araks River actually takes place, it suggests that the decrease would mainly be caused by development activities in Turkey.



(1) Koroglu Dam (planned)
(2) Besikkaya Dam (planned)
(3) Arpacay Dam (Akhuryan Dam)
(4) Bayburt Dam (under construct
(5) Demirdoven Dam

Figure 4-2.2 Confluence point of Akuryan River to Araks River

As for the Vedi project, related Armenian agencies consider it possible to indirectly contribute to raising the discharge level in the Araks River, a trans-boundary stream, by abolishing intake by pumps at three stations along the Araks River and also by returning surface water which was hitherto taken from intakes into this trans-boundary stream.

Different from the construction of reservoirs in the Kaps and Vedi projects, that of the Yeghvard

project does not dam up natural streams, but temporarily stores discharge from the Hrazdan River during the thawing season (into the regulating reservoir) through the existing Arzni-shamiram canal, thereby making use of it for irrigation during the dry season. Accordingly, a newly constructed reservoir does not bring about any change in the water resource environment at the downstream of the stream. Likewise, as shown in Figure 4-2.3, no trans-boundary river flows into Lake Sevan (except of diversion by tunnel by separation of drainage watershed). This is to say that from Lake Sevan/the Hrazdan River, different from the Akhuryan River in the Kaps project and the Araks River in the Vedi project, is the only one water resource which can be self-developed by Armenia alone. Thus, the Study Team well understands the incongruous sense of the Armenian nation, why other countries intervene on water use of the Hrazdan River that receives water from Lake Sevan only.

Furthermore, there emerges a growing concern on the drawdown of the groundwater level in the Ararat Plain (at maximum 15m) and its water quality deterioration. Though a detailed investigation is presently not progressed, this change may hereafter possibly affect water volume and quality of the Araks River, a trans-boundary stream. According to TIWRM (by WB), the current volume of lifted groundwater by pumps has increased by about 600 million m^3 as compared to that in 2008, and it is mostly used for fish ponds, but that for irrigation by pump is included, accounting for about 5%. Because the downstream part of the existing Yeghvard irrigation project and water source of irrigation by pump bound for the entire beneficiary of the Vedi irrigation project are located in Ararat Plain, abolishment of pumping stations can contribute to mitigation of problems on trans-boundary streams.

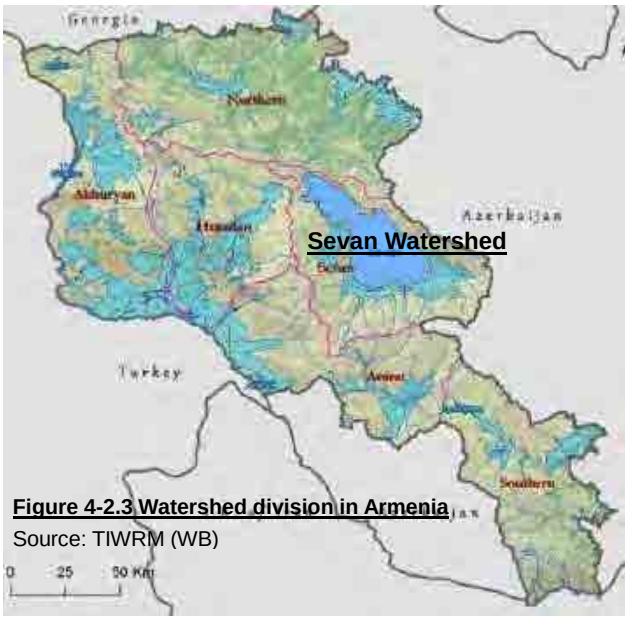


Figure 4-2.3 Watershed division in Armenia
Source: TIWRM (WB)

CHAPTER 5 RECOMMENDATIONS FOR THE YEGHVARD IRRIGATION DEVELOPMENT PROJECT

5-1 Agricultural Development

5-1-1 Farming Support

As described in "sub-chapter 3-2-4", farmers in the target irrigation area face a number of difficult issues to manage their farming. The Yeghvard Irrigation Project aims at improving their irrigation condition which is a highlighted concern to the farmers. It is recommended that comprehensive supporting measures to address the farmers' issues be taken together with the Project in order to develop the regional agriculture and to improve the farmers' welfare in accordance with SADS.

Table 5-1.1 shows the farmers' issues confirmed through a series of filed surveys conducted by the JICA study team and recommended measures to address them. While a part of the measures has already been taken by the Government of Armenia, the remaining measures should also be taken effectively together with the Project in order to increase the Project's impact. Prioritization of the measures and clear demarcation between the Government's roles and the private sector's roles in the measures shall be vital to ensure effective implementation.

Table 5-1.1 Measures to be Taken to Address the Issues Concerned by Farmers

Issues	Measures
Technical consultation service is not provided	To encourage agricultural research to introduce applicable crops and to develop practical technologies at farmer level, based on farmers' needs
	To disseminate the crops and the technologies through reinforcement of agricultural extension system targeting individual farmers
Production cost is high Lack of farm-machinery	To promote free business competition by encouraging private sector participation in agricultural inputs/farm-machinery business
	To exempt or reduce import duties from agricultural inputs/farm-machinery
	To decrease in obstacles to import agricultural inputs/farm-machinery
	To encourage a used farm-machinery trading business
Agricultural inputs quality is not good enough	To promote free business competition by encouraging private sector participation in agricultural inputs business
	To impose a workable quality standards & control system including inspection and penal regulations
Irrigation water is not enough	To rehabilitate irrigation canals, especially at the field level
	To develop and rehabilitate internal irrigation networks
	To educate water saving technology to WUA members
	To promote a drip irrigation system, especially in the orchards
	To regulate ground-water use properly
Agricultural credit is not accessible	To promote a favorable agricultural credit scheme for farmers supported by the Government
	To educate farmers on how to make an effective use of agricultural credit for their farming business, and benefits & their obligations
Market access is difficult Market is being saturated (seasonally)	To introduce and develop farming technology of forcing or inhibiting cultivation of vegetables
	To introduce and develop new vegetables, fruits, flowers and ornamental plants
	To promote business competition by encouraging private sector participation in farm products marketing including exporting
	To promote hygiene-oriented agro-processing industries by encouraging private sector through free competition
	To educate farmers about what is marketing under a free economy system, including advantages and disadvantages comparing the former state-controlled marketing system
	To interface farmers (a group) with excellent private traders to develop a partnership in marketing
	To disseminate updated market information to farmers including prices of farm products
	To develop and rehabilitate rural road networks

Source: The JICA Study Team

5-1-2 Export Promotion

Promotion of export-oriented production is a main goal of SADS. The export promotion is also an important strategy to maximize the Project's effect. While SADS clearly stipulates "to shape favorable conditions for promoting export-oriented production" as one of three pillars of the goal, Table 5-1.2 shows the expected favorable conditions and necessary measures to realize them. The same as farming support measures, prioritization of the measures and clear demarcation between the Government's roles and the private sector's roles in the measures shall be vital to ensure effective implementation. Since the private sector plays a main role in the marketing sector and the Government roles are relatively small compared to the farming support measures, it is recommended that the Government remain in the background and support the private sector in order to maximize its potential.

Table 5-1.2 Favorable Conditions to Promote Export-oriented Productions

Favorable Conditions	Necessary Measures
Diversified production of crops/varieties in accordance with the demand of target markets	• To carry out a market research at target markets • To develop/introduce new crops and varieties based on the market research • To disseminate necessary farming technology to grow the new crops or varieties to farmers
Continuous harvesting of vegetables throughout a year	• To develop/introduce new farming technology to harvest vegetables in autumn and winter seasons • To disseminate the farming technology to farmers • To organize farmers in a certain area to coordinate their harvesting time in order to ensure a continuous harvesting
Reliable and stable export marketing throughout a year	• To organize farmers to promote joint-marketing • To develop a partnership between farmers and competent private traders, as well as among traders • To develop long-term storage system
Cost reduction of production and logistics	• To increase productivity of farmers • To develop and rehabilitate rural road networks • To promote regulatory reform and fair competition in agri-business, e.g. inputs-supply, marketing, processing, foreign trade, etc. • To encourage and foster private sector in agri-business • To develop a favorable credit scheme for farmers as well as for private agri-business companies
Production of high standard products	• To educate all stakeholders i.e. farmers, traders, processing factories about required quality standards for target markets • To develop/introduce new crops and varieties to meet the quality standards • To disseminate necessary technology to improve quality standards to all stakeholders • To promote fair competition in agri-business
Production of safety & security crops and fresh farm products	• To educate farmers about idea of safety and security crops (quality factors are not only taste and appearance) • To introduce and disseminate a GAP (Good Agricultural Practice) system among farmers • To develop a workable national pesticide control system, i.e. registration, market inspection, residue inspection, etc. including penalties • To reinforce the national plant and animal quarantine control system
Production of safety and security processed foods	• To educate agri-business about idea of safety and security foods • To introduce and disseminate ISO 22000 and an HACCP(Hazard Analysis and Critical Control Point) system among agri-business
Promotion of Armenian farm products in target markets	• To advertise Armenian farm products in target markets • To send Armenia farm products to international competitive fairs and exhibitions

Source: The JICA Study Team

5-2 Use of Water Sources, Area of Irrigated Perimeter, Irrigation System

5-2-1 Examination on Water Balance

The water balance of the Yeghvard irrigation development project plan is herewith calculated based on related hydrological and meteorological data, a farming plan and water intake conditions of other irrigation systems in the Hrazdan River. The premises of this water balance calculation are determined, referring to information collected through the PIU.

Table 5-2.1 gives the premises of water balance calculation, while Figure 5-2.1 shows a diagram of the irrigation network, including the beneficiary area of said Yeghvard project. Also, Table 5-2.2 shows the volume of water demand in beneficiary areas (other than the aforementioned project area) which also utilize water from the Hrazdan River and Lake Sevan.

Table 5-2.1 Premises of Water Balance Calculation

Item	Content
Area of irrigated perimeter	12,200ha
Adopted sites of discharge observation	Hrazdan (Hrazdan River) Lusaker (Hrazdan River) Ashtarak (Kasakh River)
Property of discharge data	Data of 10-day mean (2003-2012)
Standard documents of irrigation	Norms and regimes of Irrigation of agricultural crops for the irrigable lands of the Republic of Armenia (Appendix D-10)
Regions (Marz) where gross duty of water is referred	Armavir Marz (Heavy sand) (Wheat, Vegetable, Grape, Alfalfa, Fruit, Maize [Other])
Other irrigation beneficiaries	Arzni-shamiram 2nd part ,Lower Hrazdan 2nd part, Artashat canal, Other canals
Available maximum section from Arzmi-Shamiram canal	$22m^3/s$
Water conveyance ratio	46.8% (Main Canal (72%), After Secondary Canal (65%))
Evaporation	40mm/month (The average value of the amount of evaporation in the Yeghvard observation point is adopted. It assumes that it evaporates from 3 km x 3 km as an amount of evaporation loss in 0.14 m_3/s)
Infiltration loss from reservoir	The maximum of 0.61 MCM/month in the F/S report (Armvodproject) is adopted. 0.61MCM / 30 day/86400 second $x10^6$= $0.24m^3/s$ is assumed as a infiltration loss from reservoir.

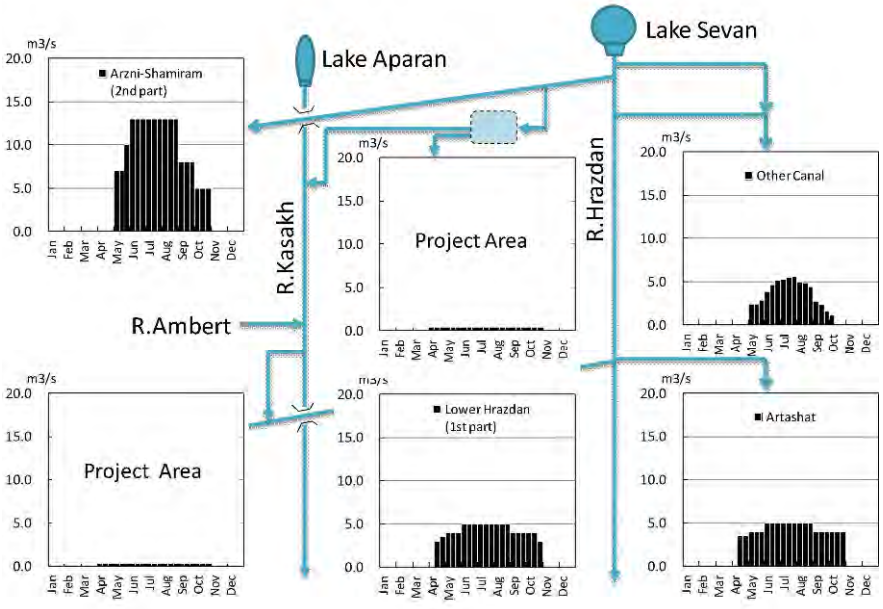


Figure 5-2.1 Diagram of Irrigation Network Used in Water Balance Calculation

Table 5-2.2 Water Demand by Beneficiaries other than Those of the Yeghvard Irrigation Development Project

Irrigation Area	Demand
Arzni-shamiram 2nd part	159.1 MCM
Lower Hrazdan 2nd part,	76.2 MCM
Artashat canal	77.6 MCM
Other canals	52.6 MCM
Total	365.5 MCM

*) PIU, in this table water conveyance efficiency is already taken into account.

5-2-2 Water Demand in the Yeghvard Irrigation Development Project

In compliance with the standard document of irrigation water, the requirement in this project is calculated. Based on the irrigation standard "Norms and regimes of Irrigation of agricultural crops for the irrigable lands of the Republic of Armenia", the required amount of water of each crops is shown in Appendix D-10. The irrigation area is listed in Table 5-2.3. 46.8% is to be applied to the water conveyance efficiency of canals in conformity with the premises of the calculation by PIU as tabulated in Table 5-2.4. In this context, improvement of water conveyance efficiency of canals is an imperative issue for Armenia. It follows that water balance calculation in the case of the improved conveyance efficiency is also assumed in this balance examination. In this regard, canal rehabilitation is assumed so that the canal water conveyance efficiency of the main canal, secondary and further downstream canals is ameliorated by 3% from the existing level, respectively, and water demand is calculated based on this premise (Table 5-2.5 and Table5-2.6) (see Appendix D-11). In addition, in the section in which the WB implemented the canal repair works, 85% conveyance efficiency is measured and the assumption of the improvement in 3% of conveyance efficiency can be assumed to be a minimum improvement level.

In improvement in conveyance efficiency, repair of canal wall and bottom, and the construction that prevents the leakage of water at the intake gate, etc. can be considered. There is also the section where the WB has already rehabilitated, and the canal design drawings have draw by WB. From now on, the fund for canal repair is a big subject. In addition, participation of WUA is indispensable to canal rehabilitation and maintenance activities for secondary and tertiary canals. Then, maintenance activities implemented by WUA is important.

Table 5-2.3 Beneficiary Area

Crop	Irrigation area (ha)
Wheat	2,735
Vegetables	2,245
Vineyard	1,810
Alfalfa	1,340
Fruit orchard	1,580
Other (maize)	2,490
Total	12,200

Table 5-2.4 Canal Water Conveyance Efficiency Assumed in Water Balance Calculation

Target irrigation facilities	Water conveyance ratio (present state)	Water conveyance ratio (present + improved by 3%)
Main canal	72%	75%
Secondary ~ Tertiary ~ Parcels	65%	68%
Comprehensive (main canal ~ parcels)	46.8%	51.0%

Table 5-2.5 Irrigation Water Requirement (IWR)

Irrigation Area	Irrigated Area (ha)	Demand (MCM)
Wheat	2,735	22.2
Vegetable	2,245	37.4
Grape	1,810	27.7
Alfalfa	1,340	23.2
Orchard (Fruit)	1,580	13.4
Maize (Other)	2,490	21.1
Total	12,200	145.0

*water conveyance ratio (46.8%) is already taken into account

Source: PIU

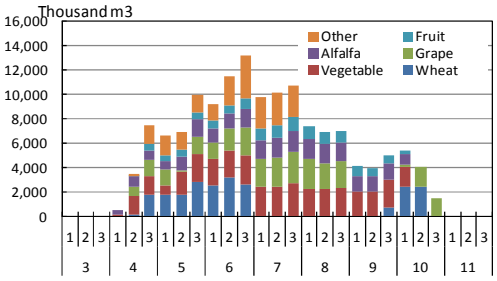


Figure 5-2.2 Irrigation Water Requirement

Table 5-2.6 Irrigation Water Requirement (in the case of improved water conveyance efficiency by 3%)

Irrigation Area	Irrigated Area (ha)	Demand (MCM)
Wheat	2,735	20.4
Vegetable	2,245	34.3
Grape	1,810	25.3
Alfalfa	1,340	21.3
Orchard (Fruit)	1,580	12.3
Maize (Other)	2,490	19.5
Total	12,200	133.1

*water conveyance ratio (51.0%) is already taken into account

Source: PIU,

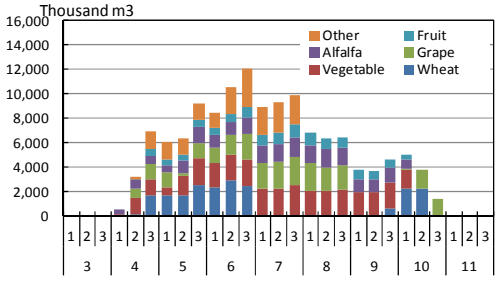


Figure 5-2.3 Irrigation Water Requirement (in the case of improved conveyance efficiency by 3%)

5-2-3 Water Balance Calculation (single year calculation)

River discharge during water depleting periods is calculated by probability calculation to examine available water volume to divert into the Yeghvard reservoir. The calculation is made with three (3) cases as listed in the Table 5-2.7. The river discharges used in this calculation are actually measured data of 10-days mean discharges during of the period 2003-2013 in the Hrazdan and Kasakh Rivers. Figure 5-2.4 shows a hydrograph of each adopted return period (the same as presented in Chapter 3).

Table 5-2.7 Relationship between the Probability Used in the Calculation and Return Period

Item	Return Period	Remarks
Equivalent to 50% probability	1/2	-
Equivalent to 75% probability	1/4	Armenian Design code
Equivalent to 90% probability	1/10	Japanese Code

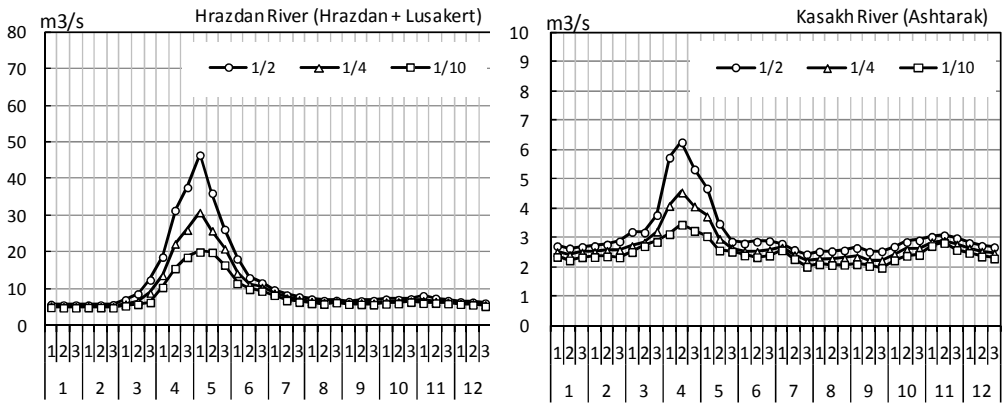


Figure 5-2.4 10-days Mean Discharges in Hrazdan River and Kasakh River

Table 5-2.8 shows the calculation results of water volume which can be diverted into the Yeghvard reservoir by applying river discharge of each return period. As a result of the calculation, it is found that the Yeghvard reservoir can store water up to 103MCM by diverting water from the Hrazdan River to the said reservoir in the case of the return period assumed at 50%. It implies that the water required in the Yeghvard irrigation project area is sufficiently met by the discharge from the Hrazdan River alone, not depending on any water from Lake Sevan (See Appendix D-12).

On the other hand, in the cases of droughty discharges under 75% probability as well as those under 90%, the available water volume that can diverted into the Yeghvard reservoir declines to 57MCM and 23MCM, respectively, since the discharges in the Hrazdan River are not sufficient to divert. As a result, the Yeghvard irrigation project area is obliged to rely on 31MCM (in the case of the discharge under 75% probability) and 66MCM (discharge under 90% probability) of water from Lake Sevan respectively, under the assumed two levels of probability.

Table 5-2.8 Return Period and the Result of Water Balance Calculation

Probability	Return Period	Demand (MCM)	Lake Sevan			Hrazdan	Possible quantity for Yeghvard Reservoir
			Others	For Yeghvard	Total		
50%	1/2	145.0	177	0	177	271	103
75%	1/4	145.0	190	31	221	206	57
90%	1/10	145.0	204	66	270	159	23

As such, though the river discharge during the period of March-May can be stored in the Yeghvard reservoir during years of average discharge, the available water volume for diverting to the reservoir curtails during years of droughty river discharge, leading to dependence on Lake Sevan for balancing the deficit volume. Taking the above-mentioned examination into consideration, it is understood that it is necessary to calculate water balance of the reservoir covering plural years for evaluating the regulatory capacity of Yeghvard reservoir.

5-2-2 Water Balance Calculation (consecutive, plural year calculation)

The Hrazdan observatory has been installed in the watershed area of the Hrazdan River in the beneficiary area of the Yeghvard irrigation development project. According to precipitation data in this observatory, the probability of annual precipitation in two recent drought years, 2008 and 2012, are given in the following table (discussed in Chapter 3).

Table 5-2.9 Probability of Annual Precipitation in Drought Years in the Case of Adopting 30 Years (1983~2012)

Year	Probability (%)	Return Period
2008	92 %	Approx 1/10
2012	67 %	Approx 1/4

The objective of water balance calculation for consecutive years is to determine the storage capacity of the reservoir so that it does not become completely empty after being used for irrigation during drought years adopted for the examination. 1/10 probability has been adopted in determining the storage capacity of reservoirs in Japan, however, in such countries as Armenia where annual precipitation has been scarce, the scale of the reservoir should be larger in order to make it tolerate even at the probability of 1/10. In this context, in light of the fact that 1/4 probability is commonly adopted as design river discharge in Armenia where available water resources are quite limited, this examination also adopts 1/4 probability as used in the Armenian design code. Here, 2012 that is approximate to 1/4 probability (actually 1/3 probability) is employed as the basal year for the examination to determine the capacity scale of the reservoir that can irrigate 12,200ha by only the stored water in the Yeghvard reservoir, even in the droughty state of discharge experienced in 2012.

Table 5-2.10 gives the result of the water balance calculation in the case of assuming the scale of the Yeghvard reservoir at 90MCM. Figure 5-2.2 illustrates the change in water storage capacity of the Yeghvard reservoir. In this case, judging from the illustrated diagram, the Yeghvard reservoir becomes empty during the irrigation period in 2012, the basal year of this examination, thus it fails to irrigate its beneficiary of 12,200ha. The deficit water volume in this case amounts to 19MCM, which is likely to be supplemented by water from Lake Sevan or by pumped water.

Table 5-2.10 Result of Water Balance Calculation for the Yeghvard Reservoir (consecutive, plural year calculation)

Case of examination and target year	Water demand MCM	Size of Yeghvard reservoir (MCM)	Dependence on Lake Sevan MCM			Dependency on Hrazdan reservoir MCM	Deficit water volume MCM
			Others	For Yeghvard	Total		
Base (2012)	145.0	90	188	0	188	196	19

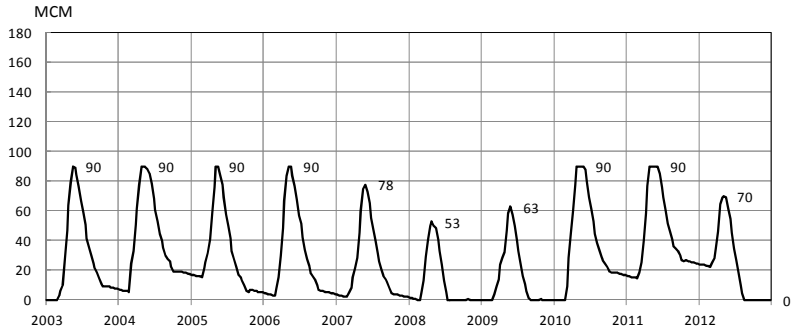


Figure 5-2.5 Change in Stored Water in Yeghvard Reservoir (90MCM)

Here, the storage volume of the Yeghvard reservoir that may not lead it to empty even under the droughty state is calculated. The result of this calculation indicates that if the storage volume is designed at 110MCM, the reservoir becomes able to irrigate the total 12,200ha. Case B of Figure 5-2.6 and case C of Table 5-2.11 show a change in the stored volume of these cases. As for the case of improved canal water conveyance efficiency, it is given in case C of Table 5-2.11.

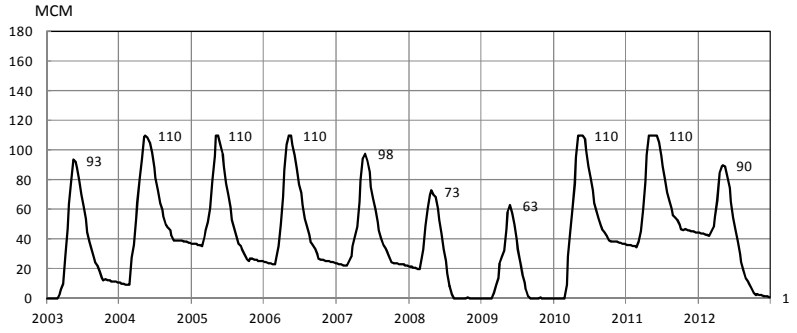


Figure 5-2.6 Change in Stored Water Volume in Yeghvard Reservoir (110MCM)

Table 5-2.11 Result of Water Balance Calculation by Different Examined Cases

Examined case	Water demand (MCM)	Yeghvard (MCM)	Lake Sevan			Hrazdan	Depended water sources for meeting deficit
			Others	Yeghvard Deficit	Total		
Base	145.0	90	188	19	207	196	Lake Sevan
A	145.0	90	188	0	188	196	Rancchabar P/S
B	145.0	110	188	0	188	196	Reservoir expansion
C	133.1	90	188	0	188	196	Canal rehabilitation (Conveyance efficiency: 51%)

5-3 Dimensions of the Reservoir

The above-mentioned examination has revealed that the dimensions of the Yeghvard reservoir changes with the change in premises on the examination. In this Study, given the following examination scenarios, the storage volume of the Yeghvard reservoir changes with the range of 90MCM-110MCM. It will be required, in the occasion of the F/S, to determine the dimensions of this reservoir in full use of further scrutinized data.

- Examination case A: Reservoir is designed at 90MCM, while the deficit 19MCM is depending on Lake Sevan,
- Examination case B: Reservoir is designed at 90MCM, while the deficit 19MCM is depending on Rancchabar pump station,
- Examination case C: Reservoir is expanded to 110MCM, without any dependency on Lake Sevan for irrigating beneficiary of Yeghvard irrigation project,
- Examination case D: Reservoir is designed at 90MCM, assuming that canal water conveyance ratio is improved.

5-4 Dam Location Plan Considering the Utilization of the Existing Embankments

1) Conditions of the existing embankments and their utilization

It is confirmed by the in-situ investigations and the laboratory tests that the existing embankments being made of sand-and-gravel materials formed mainly by the mixture of hard cobbles and gravels are sufficiently compacted and equipped with a high enough shear strength.

The original idea of the structure of the Yeghvard reservoir is a sand-and-gravel zone with an inclined core zone. This core zone connects to the anti-infiltration structure constructed at the bottom of the reservoir and by the works of both a core zone and an anti-infiltration structure the storage function of the reservoir is secured. At the time of the F/S in 1999 (at that time the reservoir capacity was revised to 90MCM), this original idea/formation was not changed. It is better to follow this original idea and structural formation of the reservoir for future design to utilize existing embankments made of sand-and-gravel as a part or the main portion of dam body. However, the proposed shape of the dam body at the F/S term in 1999 is the same as the cross-section modified by the quake resistant review study in 1989 except for the dam crest portion. This portion is removed to make the dam height low and this formation is understood not to be designed based on the study result in terms of stability and anti-infiltration ability. Therefore, at the authentic F/S by Japan the cross-sectional shape of the dam body, together with the evaluation of soil parameters of embankment materials such as sand-and-gravel and sandy clay, shall be studied from the beginning as though the existing embankments are to be utilized.

2) Planar shape of the reservoir

The planar shape of the reservoir is decided from the viewpoints to reduce reservoir area to decrease the evaporation quantity from the reservoir surface and to decrease the construction area of high-cost anti-infiltration work at reservoir bottom as well.

- Formation of the reservoir is the approximately rectangle planar shape with the longer axis connecting Dam No.1 and Dam No.2.

- Reservoir is closed at its eastern and western ends by Dam No.1 and Dam No.2 from the viewpoint of utilizing the existing embankments.

- The formation of the northern and southern ends of the reservoir is cut-slope formation or

cut-and-bank formation aiming to make reservoir area small because these areas have a gentle slope and the water surface area becomes bigger particularly as the water level rises (refer to the figure below).

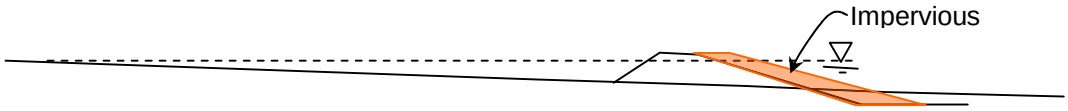


Figure 5-4.1 Image of Reservoir Edge

- The slope of the reservoir is covered not with a sheet covering but the impervious embankment as anti-infiltration works to avoid being unstable by back pressure caused by rain/melted water seeping and being stored on impervious layers such as an unconformity surface among sedimentation layers.

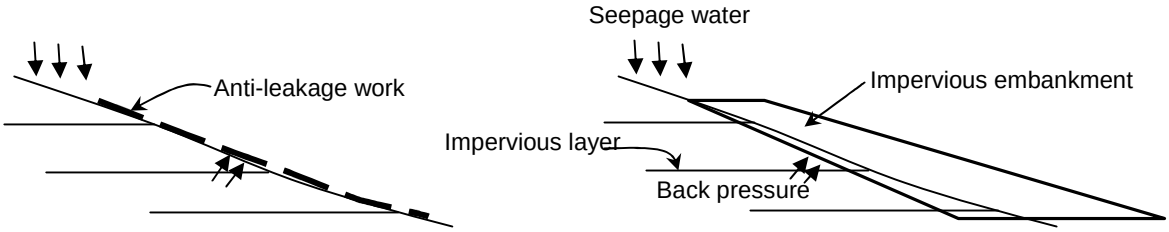


Figure 5-4.2 Image of Anti-infiltration Treatment on the Slope

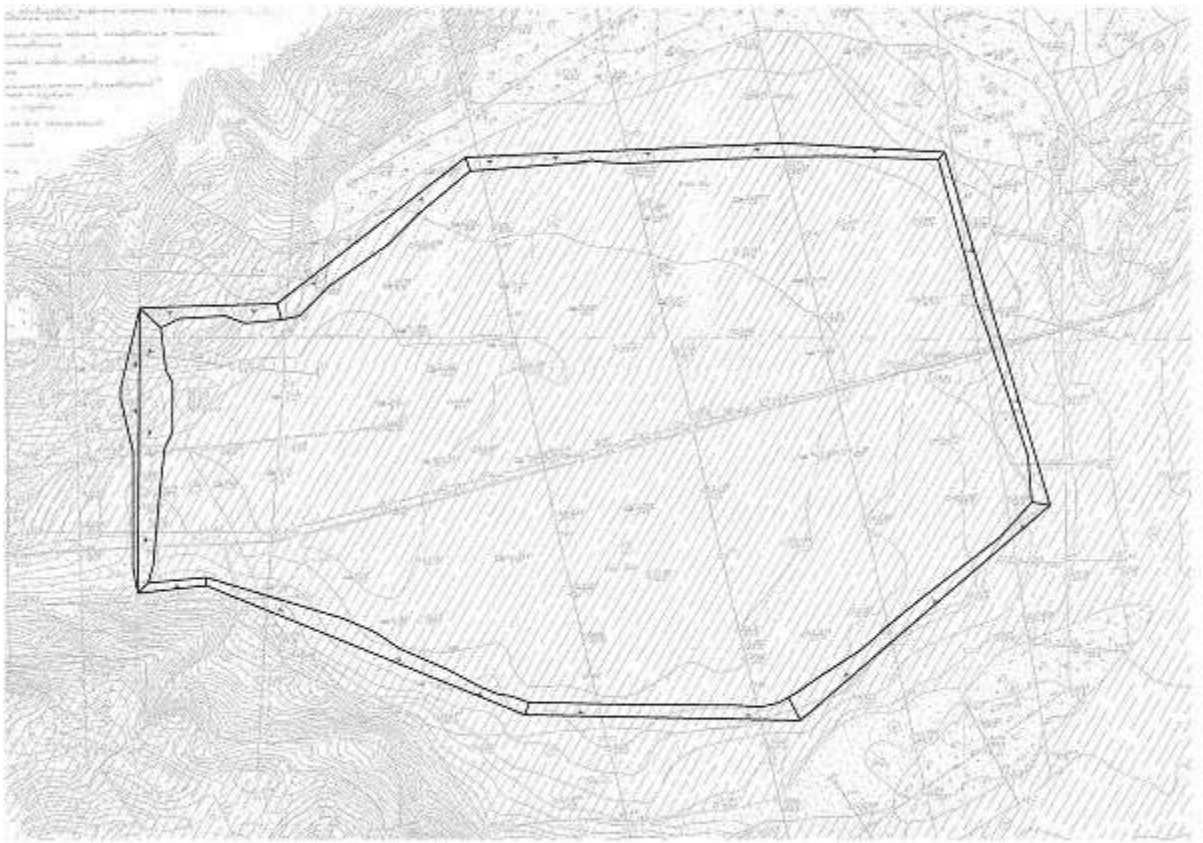


Figure 5-4.3 Planar Plan of Yeghvard Reservoir (basic image)

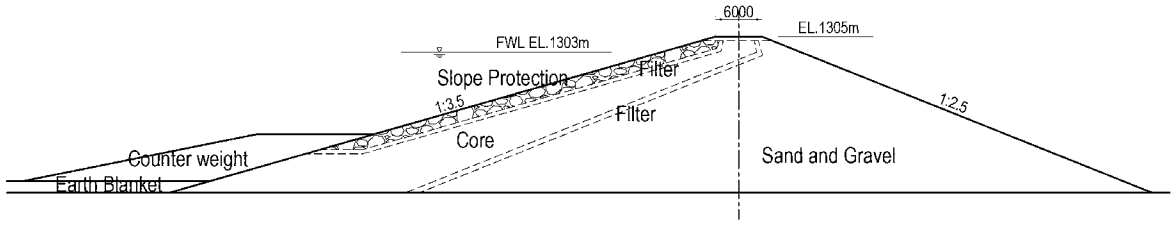


Figure 5-4.4 Cross-section of Dam Body (basic image)

5-5 Counter Measure on Infiltration Water

5-5-1 Existing Investigation and Calculation of Infiltration Water

The Russian geological survey (1983-84) revealed that the permeability of each geological formation as listed below (Table 5-5.1).

Table 5-5.1 Permeability Coefficients of Major Formations

No.	Formations	Permeability Coefficient (cm/s)
1	Recent Loamy sand, loam ($vdpQ_{IV}$)	1.97×10^{-4}
2	Sand and gravel/pebble (paQ_{IV})	5.03×10^{-3}
3	Recent Eluvial, Deluvial formation ($_{ed}Q_{IV}$)	1.63×10^{-3}
4	Late Quaternary Tuffs (βQ_{III})	4.68×10^{-3}
5	Middle Qua. Andecite lava (βQ_{II})	8.04×10^{-3}
6	Early Qua. Lap-ap-lap Q_{IV}	1.16×10^{-5}
7	Early Qua. Alluvial/proluvial sediments	3.08×10^{-3}
8	Late Pliocene, volcanic rocks	3.24×10^{-4}
9	Middle Pliocene,Pumices ($_{\beta}Q_1$)	1.57×10^{-2}
10	Andecite/Scoria ($_{\beta}N_2$)	9.83×10^{-3}
11	Andecite layer (N_1)	2.83×10^{-3}
	Ave,.	4.67×10^{-3}

As shown in the Table 5-5.1, permeability coefficients of the formations vary from 1×10^{-2} to 10^{-5} cm/sec orders, but mostly in 1×10^{-3} cm/sec order, they are quite permeable. Furthermore, the layers having high permeability (sands and gravels/pebbles) lay in the northern part of the reservoir area, and in surrounding slope zones, other highly pervious volcanic formations are distributed. The results of field permeability tests carried out by the Study also indicated almost the same high level of permeability.

Then, the Soviet report estimated the water losses by infiltration from the reservoir, depending on the water head of the reservoir, and taking into account distribution, thickness, and depths of rather hard permeable layers. The results of water losses estimated is summarized as follows (Table 5-5.2). Total water infiltration losses shall be 311 MCM/year when the dam is fully watered (in the case of 228 MCM of the reservoir capacity). However, the summary table shows the total water losses through 7 zones where any low-permeable layers, such as loamy sand or loam layers, are existing. Besides the 7 zones, there is another zone where no such low-permeable layer is distributing (the northwestern portion of reservoir area), and the total water loss only from this zone is estimated at more than 122 MCM/year. Thus, the report emphasized that the total water losses from the reservoir is absolutely not permissible and reliable anti-infiltration measures is inevitable, over the entire water reservoir.

Table 5-5.2 Summary Table of Water Losses by NPU* Levels

Zone No.	NPU elevation	Water head of Dam	Filtration block formation area	Unit filtration loss	Total water loss		
					m^3/day	m^3/sec	MCM/y
	m	m	m^2	m^3/day			
1	1,289	12	3914500	0.149	535510	6.78	213.71
2	1,294	17		0.161	629199	7.28	229.66
3	1,299	22		0.172	674517	7.87	246.20
4	1,304	27		0.184	718878	8.32	262.39
5	1,309	32		0.195	763607	8.84	278.72
6	1,314	37		0.207	808996	9.36	295.38
7	1,319	42		0.218	852472	9.87	311.15

*: NPU: Full water level of the dam (Russian).

5-5-2 Anti-infiltration Work to Reservoir Bottom

1) Necessity of anti-infiltration countermeasure

The basement of the reservoir is mainly composed of the volcanic sediment layers except for the sandy clay sedimentary layers extending on the low land surface of the basin; the volcanic sediment layers are highly pervious with permeability coefficients ranging from $k = n\times10^{-2}$cm/sec to $k = n\times10^{-3}$cm/sec. Furthermore any other impervious layers or surfaces were not found in the past geological investigations and it was reported that the ground water table existed about 100m deep from the ground's surface. Therefore, it is easily imaged that the stored water will seep out through the reservoir bottom rapidly, and so an anti-infiltration countermeasure to the reservoir bottom is necessary to secure the reservoir's storage function.

2) Construction area of anti-infiltration countermeasure

The average permeability coefficient of these sandy clay layers is $k=1.97\times10^{-4}$cm/sec according to the past borehole permeability test results. Generally, the permeability coefficient is evaluated by counting the quantity of water mainly seeping out horizontally through the borehole wall. It is well-known that there is remarkable anisotropy in permeability in horizontally deposited layers transported by water flow, i.e. anisotropy between the horizontal permeability coefficient and the vertical one. In the past study $k=1.97\times10^{-4}$cm/sec was applied as a vertical permeability coefficient of the sandy clay layer, and the whole surface of this layer was recommended to be covered with an anti-infiltration countermeasure; but if a remarkable anisotropy exists in the sandy clay layer here, the vertical permeability coefficient becomes lower and there is a possibility that the construction area of an anti-infiltration countermeasure is reduced for the area covered by sandy clay layer.

Due to the aforementioned, the construction area of the anti-infiltration countermeasure is affected much by the degree of anisotropy between the horizontal and the vertical permeability coefficient in the sandy clay layer and by the effective distribution range of sandy clay with sufficient thickness as the countermeasure. (*In this study, the countermeasure is planned to be treated for whole reservoir bottom considering the estimation of construction cost for higher side.)

3) Selection of anti-infiltration work

The followings are the nominated anti-filtration measures and their outlines.

i) Earth blanket coverage method

The reservoir bottom is covered by the earth blanket layer made of compacted impervious soil. The

sandy clay lying in the reservoir basin will be applicable as the impervious soil.

ii) Watertight asphalt concrete coating method

The reservoir bottom is coated by the pavement of watertight asphalt concrete. This method is similar to the asphalt facing work of the fill-type dam with facing and is popular as the leakage control work.

iii) Low density polyethylene sheet or rubber sheet coating method

The reservoir bottom is coated by the impervious film such as low density polyethylene sheet. It is important to conduct the design considering how to avoid the damage due to faulty workmanship and to carry out the careful construction works.

iv) Bentonite sheet coating method

The reservoir bottom is coated by the impervious thin mat of betonite sheet. It is important to examine the site conditions, conduct the design considering how to avoid the damage due to faulty workmanship and to carry out the careful construction works.

v) Soil-cement coating method

The reservoir bottom is coated by soil-cement. Soil cement has a long history of being used empirically for small-scale waterway construction, ground improvement works and so on but has rare example of being used as an anti-infiltration work to wide area.

vi) Imperviousness-strengthened earth blanket coverage method

The reservoir bottom is covered by an earth blanket layer which imperviousness is strengthened by mixing bentonite powder with sandy clay soil or by producing a thin mat of bentonite powder between the layers of sandy clay soil. This method is the improved one of iv) aiming to advance the economy and the construction reliability/performance.

The comparison results of measures are shown in the Table 5-5.3.

The soil-cement coating method is assumed to be the first candidate from the viewpoint of economy and construction reliability/performance, however it is necessary to confirm through a laboratory test if sufficient imperviousness can be obtained, and it shall be confirmed if some hazardous chemical such as hexavalent chromium liquate comes out as well. The second candidate is the imperviousness-strengthened earth blanket coverage method; but this method also requires a laboratory test to confirm its applicability. In the cases of Rubber Sheet and Bentonite Sheet, applicability is judged based on the market conditions in Armenia. The priority shall be given to the former at this stage because the product size is far larger than that of the latter and cost effectiveness is assumed as high. The watertight asphalt concrete coating method is rejected from the beginning for its high cost. The earth blanket method is also rejected as the permeability coefficient of soil cannot be lowered even if its anisotropy is considered and the anti-infiltration function of the layer is not sufficient to such a wide area of the reservoir bottom.

Table 5-5.3 Comparison Results of Anti-infiltration Works to the Reservoir Bottom

Method	Outline and past record	Self-holding ability against seismic movements	Foundation works	Protection works	Repair	Approximate construction cost (by price in Japan)
Earth blanket coverage	$k=5\times10^{-6}$cm/sec An earth blanket of 1.5 m thick does not function enough as anti-infiltration countermeasure.	*Reliability is low due to its thickness more than 1.5m.				
Watertight asphalt concrete coating	$k <=1\times10^{-8}$cm/sec, A lot of track records as the facings of fill-type dams and in the waste repository.	A lot of track records as the facings of fill-type dams have been achieved in Japan.	Necessary	Not necessary especially (It is desirable to be kept under water.)	Damaged portions shall be found by the movement of floats on the water surface.	150 USD/m^2 (single structure with 3 layers, t=16cm)
Low density polyethylene sheet or rubber sheet coating	$K<=1\times10^{-12}$cm/sec A lot of track records in irrigation ponds and waste repositories, A large size production is in the market, It is important to conduct the design considering how to avoid the damage due to faulty workmanship and to carry out the careful construction works.	Very high	Necessary (30cm thick spreading and compaction of sandy clay layers)	Necessary (50cm thick spreading and compaction of sandy clay layers)		45 USD/m^2 (t=1.5mm)
Bentonite sheet coating	$K<=5\times10^{-9}$cm/sec A lot of track records in irrigation ponds, No large size production is in the market, It is important to examine the site conditions, conduct the design considering how to avoid the damage due to faulty workmanship and to carry out the careful construction works.	Very high	Necessary (30cm thick spreading and compaction of sandy clay layers)	Necessary (50cm thick spreading and compaction of sandy clay layers)		44 USD/m^2 (t=6mm)
Soil-cement coating	$k=5\times10^{-8}$cm/sec A long history of being used empirically for small-scale waterway constructions, ground improvement works but rare example of being used as an anti-leakage work to wide area, Human errors in construction works shall be avoided, Permeability coefficient must be confirmed by the laboratory and field test.	Low *required a layer with masonry joints for inducing cracks	Not necessary	Not necessary (It is desirable for the target layer to be kept under water to avoid the cracks due to temperature alteration.)		14 USD/m^2 (t=30cm×2layers)
Imperviousness -strengthened earth blanket coverage	Improved method of Bentonite Sheet coating method aiming to advance economy and construction reliability/performance of A few examples of construction, but the bentonite powder is commonly used as the material for anti-leakage countermeasure.	Very high	Not necessary	Not necessary (It is desirable for the target layer to be kept under water to avoid the cracks due to drying.)		18 USD/m^2 (t=1cm×2layers)

5-5-3 Management and Monitoring of the Reservoir

1) Monitoring of the dam body

Monitoring of the dam body shall be done on Dam No.1 and Dam No.2 which close the basin mouth to the outside and affect the people's safety in the downstream area. The monitoring targets are to be an abnormal settlement, displacement or deformation caused by earthquakes or consolidation phenomena and the leakage from the dam body.

a) Abnormal settlement, displacement or deformation

Target points of observation shall be installed on the dam crest and embankment slopes with suitable interval; and the control point shall be installed on the firm ground of abutment. An abnormal behavior shall be monitored by measuring the relative displacement of each target point against the control point. The measuring shall be done periodically and occasionally after an earthquake.

b) Leakage

Infiltration water through the inclined core zone shall be caught by the filter zone and flow down in it toward its bottom. By utilizing this structural system, the leakage water, i.e. infiltration water, shall be gathered in a perforated pipe laid at the bottom of the filter zone, led by a connected pipe toward the downstream, and monitored at the outside of the dam body.

2) Monitoring of leakage through the reservoir bottom

The leakage through the reservoir bottom shall be monitored full-time by the groundwater observation wells installed along the edge of the reservoir or occasionally by throwing floats on the water surface and pursuing their movements at the time of low water-level condition. Monitoring by the latter way shall be effective to grasp the leakage point; after grasping the problem point by this way it is possible to confirm the conditions of/around the point concerned visually and conduct repair works if necessary.

3) Safety management to the visitors

The visitors' activities shall be controlled and the facilities necessary for keeping their activities in safe shall be prepared in consideration of the access from the public roads to the reservoir, the open-door program to the public as the recreation space, and the arrangement plan of recreational facilities.

5-6 Seismic Analysis and Survey

5-6-1 Establishment of Methodology and Standard for Seismic Analysis

1) Methodology of calculation of seismic acceleration for design and reservoir stability analysis

As already mentioned in "2-6-2 Seismic Analysis Standard," to calculate seismic acceleration according to present seismic codes, a preliminary analysis, the Eigen analysis with a 2-dimensional FEM model, is required. Additionally, a reservoir stability analysis using a calculated seismic analysis according to the present seismic codes is more complicated than the previous one.

Although PIU has a package of software for reservoir stability analysis, it may be difficult to carry out analysis according to present seismic codes using this software because this software is an old version.

To deal with this situation, the following two (2) measures can be considered,

i) Carry out calculation of seismic acceleration and reservoir stability analysis according to present seismic codes

Since it may be difficult to carry out with the PIU's present software, creation of new software may be required.

ii) Arrange seismic acceleration to be applicable to present software

This measure is to establish a simple method to calculation seismic acceleration based on present seismic codes. In this case, a preliminary analysis, the Eigen analysis, is not required. However discussion with related agencies about methodology for arrangement is required, because this measure means to establish a seismic design standard.

In Japan, reservoirs designed using seismic acceleration as prescribed in Japanese standards had almost no major damage as a result of a large earthquake, such as The Southern Hyogo prefecture earthquake in 1995 (Magnitude: 7.3). Considering this situation, if the number of seismic acceleration calculated according to i) or ii) mentioned above (which will be selected as the project continues) is much bigger than the number prescribed in the Japanese standard, the measure to calculate seismic acceleration will be discussed again if necessary.

2) Cases of reservoir stability analysis

Generally, a reservoir stability analysis is carried out for some cases combining some water levels, seismic accelerations and required safety factors. In Japan, necessary cases (combination) are prescribed in the standard while there is no standard/guideline prescribing necessary cases in Armenia. Additionally, analysis cases of the Kaps and Vedi reservoirs are not the same. The necessary cases in the Japanese standard and analysis cases of the Kaps and Vedi reservoirs are show in Table 5-6.1.

In Armenia, there are more than 100 reservoir plans, including Yeghvard, Kaps and Vedi. Therefore, a common view for a basic analysis case is required. Of course additional analysis cases based on specification of target reservoirs are acceptable, but a basic analysis case shall not be determined by the project.

Table 5-6.1 Analysis Cases (Combination of Water Level and Required Safety Factor) for Reservoir Stability Analysis

Water Level	Standard in Japan		Kaps		Vedi		
	Normal	Earth quake	Normal	Earth quake	Normal	Earth quake	Emergency
Dam Crest (Emergency Water Level)	-	-					1.0
Design water level / Maximum water level	1.2	-	1.3	1.1	1.2		
Normal Water Level / Full Storage Level	-	1.2	1.5	1.1	1.2	1.2※2	1.0※2
Middle water level	-	1.2					
Empty (Completion of construction)	-	1.2*1	1.3	1.1			
Emergency water dropping	-	1.2*1	1.3	1.1	1.2		

*1: 50% of calculated seismic acceleration

*2: Earthquake" targets the maximum number of earthquakes that are likely to occur during the economic life of the structure and "Emergency" targets the maximum number of earthquakes likely to be experienced in the area.

5-6-2 Implementation of Micro Seismic Zoning Survey

In present seismic codes, the required procedure to set the seismic acceleration for design (A in the formula mentioned in "2-6-2 Seismic Analysis Standard") is determined by class of reservoir as follows:

- F/S for class I and detailed design for class II, III and IV reservoir; seismic acceleration can be selected based on the figure described in seismic codes (show Figure 5-6.1).

- For detailed design of class I reservoir, acceleration shall be determined by survey.

Required survey for class I reservoir is called as "Micro Seismic Zoning" survey. Seismic acceleration

at the reservoir site is determined based on the results of geological investigation. The outline of the survey is shown as below.

First Stage

- Typical geological category at reservoir site is evaluated.
- An active fault which would be the source of an earthquake that could cause the most serious damage to the target reservoir is evaluated using a topographic map with the scale 1:200,000.

* The target active fault is selected considering the distance from the target reservoir site, the magnitude of the earthquake and the typical soil type of the reservoir site. For example, in Figure 5-6.1, Active fault 1: magnitude is small but distance from site is short while active fault 2: magnitude is great but distance from site is far. These active faults are evaluated and an active fault which will be the source of earthquake affecting bigger damage to target reservoir is selected from two (2) candidates.

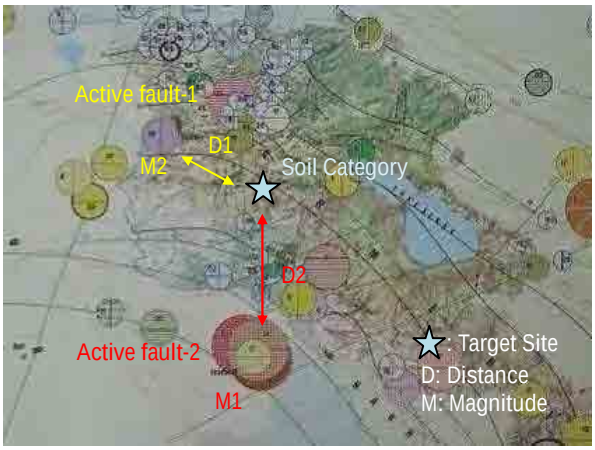


Figure 5-6.1 Image of Parameter in First Stage

Second stage

- Detailed geological structure at reservoir site is evaluated using topographic map with scale 1:1,000 - 2,000.
- Response of each geological structure at reservoir site to earthquake which affects most serious damage to target reservoir and its source is an active fault selected in first stage is evaluated.
- Seismic acceleration for design is evaluated.

* There are some measures to evaluate response of each geological structure, for example 1) observe response to manmade small scale quake, 2) observe actual earthquake motion at site. The procedure mentioned below is a sample of 1).

The importance of this kind of survey is not only to determine seismic acceleration for design but also to be a good example for future projects. Experiences of this kind of survey are accumulated, analyzed and utilized to revise the design or survey standards.

On the other hand, since a Micro Seismic Zoning survey was conducted by the Soviet Union and the members of surveyors at that time are now working at an Institute or private company, there is no one in PIU having experience of Micro Seismic Zoning survey.

Considering this situation, even though the Yeghvard reservoir is classified as class III and Micro Seismic Zoning survey is not required, to be a good example and experience in Armenia, Micro Seismic Zoning is expected to be carried out in the Yeghvard project.

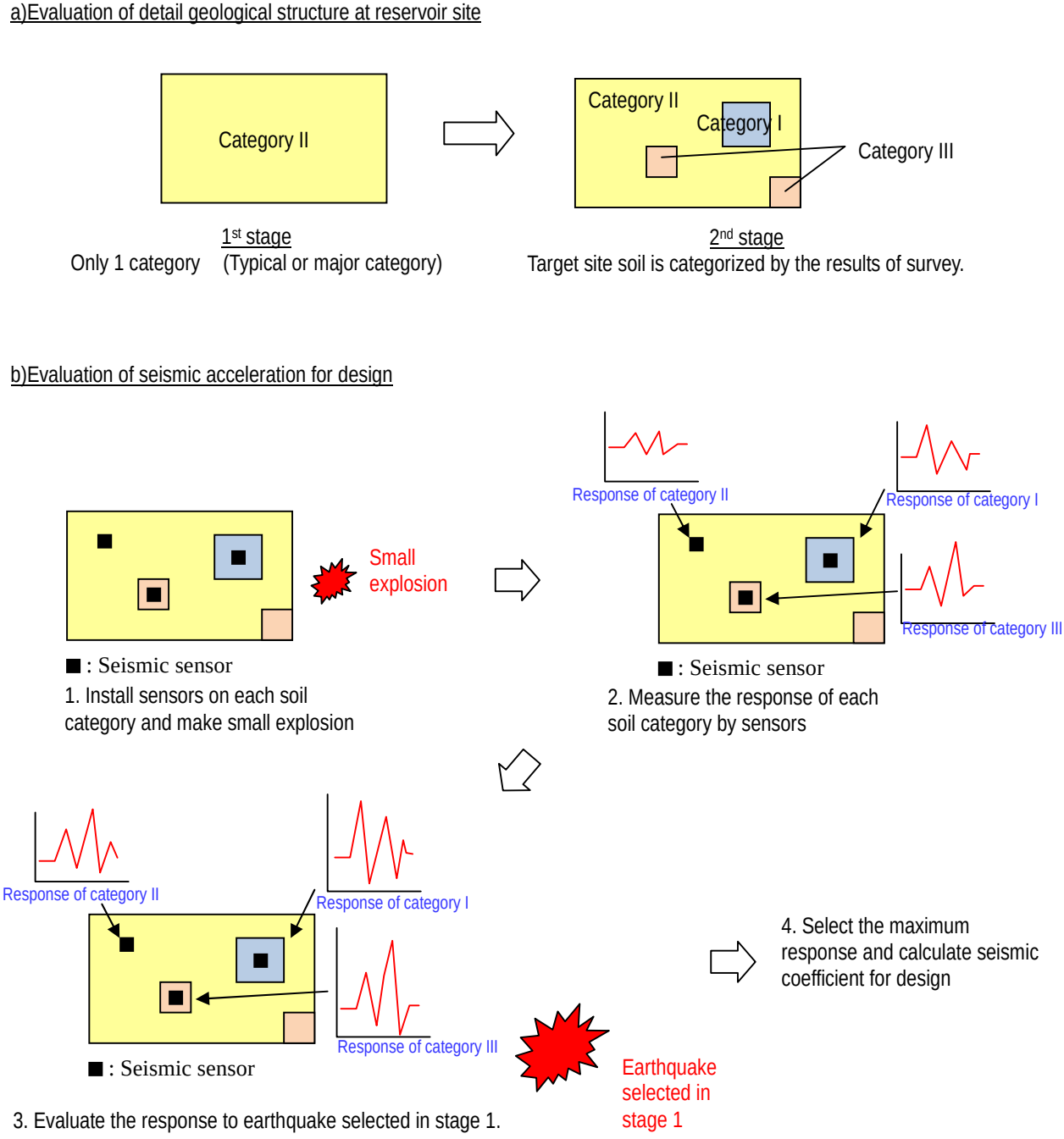


Figure 5-6.2 Outline of Micro Seismic Zoning Survey

5-7 Overall Cost Estimation and Project Benefits (Outline)

1) Overall project cost estimation

The base of project cost estimation amounts to 193 million USD as of the date of the request by the Government of Armenia on the Japanese reimbursable fund cooperation as given in Table 5-7.1 (refer to table below, the breakdown of this amount is shown in Appendix-F). The table (below) shows the sum of the above basic cost and the amount of the additional ones, the necessity of which is made clear in this Survey, including costs of: N-11) rehabilitation of Kasakh intake and N-12) improvement

of secondary and tertiary canals with terminal water use facilities (refer to Figure 5-7.1). In addition, the cost adding N-14) price escalation (in 2013), N-16) consultant fee, N-18&19) contingencies etc. to the above amount is given in the lower part of Table 5-7.1, totally amounting to 193 million USD. In this estimation, the costs of N-11) and N-12) are tentatively estimated as 50% of improvement costs related to the consolidation of irrigation facilities in the Project, respectively, hence a more detailed re-examination of this amount will be required in the authentic F/S. As concerning consultant fees and contingencies, the F/S report of Kaps was referred to.

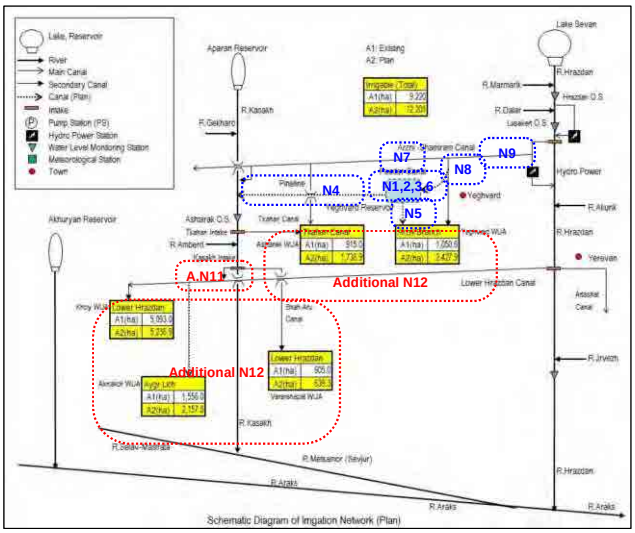


Figure 5-7.1 Location of Construction sites

Table 5-7.1 Overall cost estimation

					iii) Rubber sheet iv) Bentonite sheet	v) Soil cement	vi) Imperviousness strengthened earth blanket
				Construction cost in Japan (USD/m2)	**45**	**14**	**18**
				Conditions	**Cost for dikes**	**Coating area**	**Armenian rate**
As of March 2013		**1 USD=415AMD**			**200%**	**6,000,000m2**	**80%**
No.	Component	Main works	Estimated construction cost				
			0)Bentonite sheet based on Armenia request A=10,000,000 m2		**iii) Rubber sheet iv) Bentonite sheet**	**v) Soil cement**	**vi) Imperviousness strengthened earth blanket**
			'000 AMD	'000 USD	'000 USD	'000 USD	'000 USD
N1	Reservoir basin	Polyethlene sheet instllation; 10 million m2 (Appr. 3km x 3km) Clay-sand, alumina transferring, loading and laying; 7.5 million tons Gravel transferring, loading and laying; 5.4 million tons	32,201,555	77,594	216,000	67,200	86,400
N2	Dam No.1	Clay-sand, alumina demolition and transferring; 1.5 million tons Creating clay screen; 861 m3 Gravel transferring, loading and laying; 0.8 million tons	4,354,336	10,492	20,985	20,985	20,985
N3	Dam No.2	Clay-sand, alumina demolition and transferring; 1.2 million tons Creating clay screen; 672 m3 Gravel transferring, loading and laying; 0.8 million tons	3,887,198	9,367	18,733	18,733	18,733
N4	Irrigation outlet from Dam No.1 -->Kasakh River	Concrete work; 5,600 m3 Re-bar instllation; 336 tons Metal pipe (D=1.6m) instllation; 160m	575,971	1,388	1,388	1,388	1,388
N5	Irrigation outlet from Dam No.2 -->Arzni Branch area, Feeding pipeline 1, Simultaneously outlet 2 (DM 129+5)	Concrete work; 2,000 m3 Re-bar instllation; 120 tons Metal pipe (D=1.4m) instllation; 148m	309,570	746	746	746	746
N6	Embankment (Serving as the reservoir shore protection structure)	Removing and transferring humus (surface soil); 74,400 tons Grassing and watering; 76,000 m2	162,198	391	782	782	782
N7	Feeding canal (1) Arzni-Shamiram to the Reservoir	Removing and transferring humus (surface soil); 1.4 m3 Backfilling clay-sand by hand; 400 m3 GRP pipe D=0.6 m; 1,100 m3	46,875	113	113	113	113
N8	Feeding canal (2) Arzni-Shamiram to the Reservoir	Removing and transferring humus (surface soil); 74 m3 Backfilling clay-sand by hand; 20,000 m3 GRP pipe D=2.6 m; 3,700 m3	1,882,440	4,536	4,536	4,536	4,536
N9	Rehabilitation of Arzni-Shamiram canal	Detonation; 10,000 m3, Filling gravel, sand; 10,000 m3 Concrete work (including demolition canal, insallation); 15,000 m3 Re-bar installation; 450 tons	1,122,133	2,704	2,704	2,704	2,704
N10	**Sub-total**		**44,542,276**	**107,331**	**265,987**	**117,187**	**136,387**
	Value added Tax	(20%)	8,908,455	21,466	53,197	23,437	27,277
	Total		**53,450,731**	**128,797**	**319,184**	**140,624**	**163,664**
Added Items							
	Sub-total of N4,N5,N6,N7,N8,N9 (Canal develop	4,099,187					
N11	**Improvement of Kasakh Intake;**	**Tentative 50% of canal development??**	**2,049,593**	**4,939**	**4,939**	**4,939**	**4,939**
N12	**Improvement of Secondary /Tertiary canals**	**Tentative 50% of canal development??**	**2,049,593**	**4,939**	**4,939**	**4,939**	**4,939**
N13	**Sub-total (N10+N11+N12)**		**48,641,462**	**117,208**	**275,864**	**127,064**	**146,264**
N14	Price escalation (in 2013)	5%	2,432,073	5,860	13,793	6,353	7,313
N15	**Sub-total (N13+N14)**		**51,073,535**	**123,069**	**289,657**	**133,417**	**153,577**
N16	Consultant fee (Enginering & Construction supervision)	10%	5,107,354	12,307	28,966	13,342	15,358
N17	**Sub-total (N15+N16)**		**56,180,889**	**135,376**	**318,623**	**146,759**	**168,935**
N18	Physical contingencies (Kaps)	15%	8,427,133	20,306	47,793	22,014	25,340
N19	Finacial contingencies (Kaps)	4%	2,247,236	5,415	12,745	5,870	6,757
N20	**Total (N17+N18+N19)**		**66,855,258**	**161,097**	**379,162**	**174,643**	**201,033**
N21	Value added Tax	(20%)	13,371,052	32,219	75,832	34,929	40,207
	Grand Total		**80,226,310**	**193,316**	**454,994**	**209,572**	**241,239**

Source: PIU, The JICA Survey Team

2) Estimation of project benefits

As shown in Table 5-7.2, based on the above-mentioned overall project cost, FIRR (Financial Internal Rate of Return), cost-benefit ratio (B/C) and net present value (NPV) are calculated under the following premises as a test case.

1) Project construction period is assumed at 5 years, durable life of the constructed/rehabilitated facilities is assumed at 30 years (generation of project benefits is assumed from the 6th year).
2) As project benefits, a)beneficiary farmer's increment of farm-income brought about by the increased crop production quantity in the existing beneficiary of the irrigation area (9,220ha) and also in the newly developed irrigation area (2,980ha), b)benefits gained from livestock production by the increased amount of fodder crops produced in the irrigated project beneficiary, and c)cost-saving of pumping cost during the post-project period (that in the year of maximum consumption is adopted) are summed up in the estimation.

In this estimation, the benefits generated from the increased crop production quantity given in 2)a) and 2)b) are not obtained as a result of scrutiny based on insufficient data. Fairly significant errors would possibly hereafter arise from this estimation. Thus, the value of FIRR is nothing but a tentative indicator, so the value should be understood as highly variable with the change in the conditions of evaluation.

Besides, because the construction cost for water shielding/water tightness of the bottom area of the reservoir accounts for more than 70% of the total cost among its main cost-components, a possible change/difference in the work quantities and method(s) in this construction work gives great influence on the total project cost and the result of project evaluation. Table 5-7.2 shows comparison with project cost and FIRR, due to anti-infiltration measures, namely; a) Project cost at the time of request by Armenian government, b) Ones by rubber or bentonite sheet (both unit construction cost are almost same), c) one by soil cement, d) one by imperviousness strengthened earth blanket (with bentonite powder mixing) of which detailed calculation is listed in Appendix-F).

The Government of Armenia employed a method of covering the entire bottom of the reservoir with bentonite-sheet (10million m^2) as the work quantities and methods as of the time of the request (unit cost of the construction work: around 7.8 USD/m^2). In this Survey, it has been proposed 1)to reduce the area of coverage (10million to 6million m^2) and it is also conceivable that 2)impervious ground exists in a part of the bottom, thus saving of the construction cost is also expected. On the other hand, underestimation of the unit cost for the construction of bentonite-sheet at the time of project request is also possible, therefore, such possibility will have to be clarified in the coming authentic F/S study.

Table 5-7.2 Estimation of Cost-benefit Ratio

Anti-infiltration measure	Project Cost (M. USD)	Benefit ('000 USD)				FIRR	B/C
		Crop	Livestock	O/M reduction	Total		
a) Base of Armenian request	193	8,362	1,613	1,750	11,725	4.2%	0.45
b) Rubber or bentonite sheet	455					-1.3%	0.20
c) Soil cement	210					3.6%	0.43
d) Bentonite powder mixing	241					2.6%	0.37

In this estimation, since FIRR is tentatively calculated under the limited available data, it is required in the authentic F/S that the evaluation is made also with the Economic Internal Rate of Return (EIRR). In addition, currently, the Yeghvard irrigation area depends on Lake Sevan to secure its irrigation water requirement of 50MCM/year, however, in the post-project stage, it is expected to significantly reduce/save this rate of dependency on the Lake. As such, it is imperative to deliberately examine the method of evaluating this indicator of dependency.

Attachment

List of Parties Concerned in Armenia

Organization			Position	Name
JICA				
JICA			Armenian program coordinator	Ruzan Khojikyan
Armenian Government Office				
Ministry of Territorial and Administration	State Committee of Water Economy (SCWE)		Chairman	Vahe Hakobyan
			Chairman (previous)	Andranik Andreasyan
			Deputy Chairman	Gagik Khachatryan
		Project Implementation Unit (PIU)	Director	Felix Melikyan
			Director (previous)	Adibek Ghazaryan
			Deputy Director	Karen Grigoryan
			Engineer	Marzpet Tonoyan
			Engineer	Hamlet Harutyunyan
			Engineer	Khoren Tsarukyan
			Engineer	Varazdat Mkrtchyan
			Engineer-geologist	Ara Grigoryan
			Support Team Leader	Tigran Ishkhanyan
			Water-meter specialist	Zhora Tomrazyan
			Financial Management Specialist	Ara Hovhannisyan
			Economist	Vahan Movsisyan
			Lawyer	Gayane Karimyan
			Environmental Specialist	Martiros Nalbandyan
			Sociologist	Marine Vardanyan
			Translator	Marieta Sahakyan
Ministry of Foreign Affairs			Head of Division	Mnatsakan
			Deputy Head of Department	Artak Marutyan
Ministry of Finance			Head of Division	Larisa Harutyunyan
			Chief specialist	Stella Mkrtchyan
Ministry of Agriculture			Adviser to Minister of Agriculture	Razmik Eghiazaryan
			State Inspection of Agricultural Inspection	Vardan Ghushchyan
			Chief specialist	Abel Abrahamyan
	Foreign Relations Department			Andranik Petrosyan
	Department of Agricultural Development Programs (Statistics Information)			Hrachya Tspnetsyan
	Department of Crop Production and Plant Protection			Gevorg Harutyunyan
	Coordinating Department for Scientific and Agricultural Assistance (Extension) Center			Zaqar Gabrielyan
	Department of Land Use and Amelioration			Arthur Baghdasaryan
				Samvel Sahakyan
				Felix Egoryan
	Livestock Production and Veterinary Department			Baghdasar Kghmetsyan
Ministry of Emergency Situations	National Survey for Seismic Protection Agency		Head	Hrachya Petrosyan
			Head of Network Observation and Information Analysis Department	Valeri Arzumanyan
			Deputy Head	Ashken Tovmasyan
	Earthquake Engineering Committee		Head	Zaven Khlghatyan
	Foreign Relations Department			Nune Stepanyan
Ministry of Nature Protection			Deputy Director of the Geological Fund	Ashot Sargsyan
Sevan-Hrazdan Water Supply Agency			Director	Hobanisyan Samvel
WUA and related agencies				
WUA	Armarvir		Director	Hovhannes Petrosyan
	Khoy		Director	Seyran Sargsyan

	Aknalich	Director	Simon Abgaryan
	Shamiran	Director	Aram Parsamyan
	Ashtarak	Director	Arsen Khachatryan
	Yeghvard	Director	Mihran Hovhannisyan
	Shirak	Director	Mamicon Ghazaryan
	Noyemberyan	Director	Sevak Yesayan
Carrefour Armenia		Merchandise Manager of Fruit and Vegetable	Majid Al Futtaim
Spayka		Head, Project Management Division	Karen Baghdasaryan
Institutions			
Armvod Project Institute CJSC		Director	Yuri Javadyan
		Deputy Chief Architect	Aleksey Tarverdyan
		Chief Engineer	Gagik Ghazaryan
		Project Chief Engineer	Sochakin V.
National Academy of Sciences of Armenia, Institute of Geological Sciences		Director	Arkadi Kharakhanyan
National Academy of Science of Armenia Institute of Geophysics and Engineering Seismology after A. Nazarov (IGES NAS RA)		Director	John Karapetyan
		Head of Seismic Hazard Assessment Laboratory	Styopa Karapetyan
		Chief Specialist	Tamara Babayan
		Assistant Director of International Issues	Arusyak Manasyan
		Counselor of Director, Head of Department	Sevada Hovhannisyan
Armhydroenergyproject Institute		Technical Director	Hasmik Palanjyan
Amelioration (Land reclamation) CJSC		Chief Engineer / Head of the Operation Division	Chobanyan Samvel
		Director	Vladimir Tadevosyan
Other Donors			
World Bank		Operation Officer, Sustainable Development Department	Arusyak Alaverdyan,
UNDP		Portfolio Analyst, Environmental Governance	Armen Martirosyan
Kaps Project	KfW	Local Representative	Zara Chatinyan
	CES Consulting Engineers Saltgitter GmbH (Germany Consultant)	Team Leader	Guenther Redmer
	AHT Group AG (Germany Consultant)	Senior Irrigation Engineer	Ed Platel
		Agriculture and Rural Development, Monitoring & Evaluation	Stefan Rosenow
		Senior Consultant for Agriculture and Rural Development	Michael Gluckert
Vedi Project	French Embassy	Consultant in the issues of cultural and cooperation	Jean-Michel Kasbarian
		Attache on the issues of European cooperation	Typhaine Rampillon
Private companies			
GEORISK		Director	Hektor Babayan
		Chief Researcher	Hayk Baghdasaryan
		Translator	Yelena Abgaryan
C-labo construction laboratory		Chief operating officer	Mihran Yamukyan

Memorandum of Discussions on Data Collection Survey on Agriculture and Irrigation Sectors in relation to the Yeghvard Irrigation Project in the republic of Armenia

Yerevan, June 19, 2014

Japan International Cooperation Agency (JICA) headquarters in Tokyo dispatched a consultant team headed by Kazumitsu TSUMURA for Data Collection Survey on Agriculture and Irrigation Sectors in relation to the Yeghvard Irrigation Project (hereinafter referred to as "the JICA Survey Team") in accordance with following backgrounds;

1. Backgrounds of dispatching the Survey Team

1) After the official request for Official Development Assistance (ODA) loan was made by the Government of Armenia in June 2012, JICA had tried to gather information related to the Yeghvard Irrigation Project (hereinafter referred to as "the Project") by sending the contact missions as well as sending questionnaire in order to formulate the Project..
2) Based on the information that JICA obtained through the above 1), JICA proposed two – phased studies; a) Pre-Feasibility Study (Concept Review) and b) Full-scaled F/S and the Government of Armenia agreed the above mentioned proposal.
3) Then, JICA has dispatched the JICA Survey Team as place of the above a) Pre-Feasibility Study this time.

2. Results of the Kick-off Meeting

The JICA Survey Team has explained contents of Inception Report (Ic/R) to officials of the Government of Armenia, listed in the attachment. Main items discussed and agreed by the Armenian officials during the explanation of Ic/R are described as follows;

1) The Armenian officials have understood the approaches and methodologies as well as the schedule of the Survey shown in the Ic/R.
2) Chairman of the State Water Committee (SWC) pointed out that Government of Armenia has been discussing regularly through committees among neighboring counties regarding water right of trans-boundary rivers.
3) Also, the Chairman mentioned that the SWC has been considering of water quality maintaining not influence downstream by sewage plants.
4) Given understandings that water resource of Lake Sevan is to be conserved, the Chairman mentioned that possibility of utilizing extra water in Lake Sevan should be discussed and concluded it during the Survey period.
5) Though various uses of surface water through Hrazdan River including purposes for agriculture, industry, drinking water and hydropower are indicated in Ic/R, the drinking water is depending on groundwater, according to the Chairman of SWC.
6) The Chairman of SWC has consulted to the Director of Project Implementation Unit

(PIU) to arrange an appropriate office space in the building of PIU.

7) As for the questionnaire the Chairman of SWC mentioned that specialists from several ministries are to be involved and planned to delegate the task to them by the order of the Vice Prime-Minister.

津村和光

Kazumitsu TSUMURA
Chief Consultants,
JICA Survey Team,
Sanyu Consultants Inc. (SCI)

List of Participants

Kickoff Meeting — Place: State Water Committee Date: 19 /June/ 2014

No	Name	Organization	Position	Cell phone	E-mail	Signature
1	Andranik Andreasyan	State Water Committee	Chairman	091425445	scwe@scwe.am	signed
2	Gagik Khachatryan	State Water Committee	Deputy Chairman	091486769	scwe@scwe.am	signed
3	Adibek Ghazaryan	PIU of MoTA	Director	091420329		signed
4	Karen Grigoryan	PIU of MoTA	Deputy Director	077190703	kgrigoryan@wsdp.am	signed
5	Khoren Tsarukyan	PIU of MoTA	Hydrology specialist	094200410	tskhoren@yahoo.com	signed
6	Varazdat Mkrtchyan	PIU of MoTA	Engineer	077771983	vkit@bk.ru	signed
7	Mnatsakan	Ministry of Foreign Affairs of RA	Head of Division	077566692	m.safaryan@mfa.am	signed
8	Artak Marutyan	Ministry of Foreign Affairs of RA	Deputy Head of Department	094427210	artak.marutyan@mfa.am	signed
9	Larisa Harutyunyan	Ministry of Finance of RA	Head of Division	099214515	larisa.harutyunyan@minfin.am	signed
10	Stella Mkrtchyan	Ministry of Finance of RA	Chief specialist	093107350	stella.mkrtchyan@minfin.am	signed
11	Abel Abrahamyan	Ministry of Agriculture of RA	Chief specialist	093350515		signed
12	Hiroaki ADACHI	JICA HQ	Assistant Director	-	Adachi.Hiroaki@jica.go.jp	signed
13	Ruzan Khojikyan	JICA	Armenian program coordinator	077710760	jica.arm@gmail.com	signed
14	KazumitsuTSUMURA	JICA Study Team	Team Leader	077969362	kaz-tsumura@sanyu-con.co.jp	signed
15	Harunobu YOSHINO	JICA Study Team	Agricultural Development Planning	077969364	yoshino@task-a.jp	signed
16	Fusataka ARAKAWA	JICA Study Team	Co-Team Leader	077969460	fusa-arakawa@sanyu-con.co.jp	signed
17	Anahit Manukyan	JICA Study Team	Interpreter	099015885	mananahit1981@yahoo.com	signed

NOTE: PIU (Projects Implementation Unit) , MoTA (Ministry of Territorial Administration)

Memorandum
of the Explanatory Discussion for Draft Final Report (DFR) of the Data Collection Survey on Agriculture and Irrigation Sectors in relation to the Yeghvard Irrigation Project in the Republic of Armenia (RA)

Yerevan, November 4 and 5, 2014

Japan International Cooperation Agency (JICA) sent a mission headed by Tetsuya YAMADA, Director of Central Asia and the Caucasus Division, East and Central Asia and the Caucasus Department (hereinafter referred to as "the Mission"), incorporated with a consultant team headed by Kazumitsu TSUMURA (hereinafter referred to as "the Survey Team") to Yerevan from November 2 through 6, 2014 for the purpose of explanatory discussion for a draft final report (DFR) of the Data Collection Survey on Agriculture and Irrigation Sectors in relation to the Yeghvard Irrigation Project (hereinafter referred to as "the Survey") to the related agencies in the RA (hereinafter referred to as "the Armenian side") in accordance with following backgrounds;

1. Backgrounds of dispatching the Mission and the Survey Team

1) After the request for Official Development Assistance (ODA) loan to the government of Japan was made by the Government of RA in June 2012, JICA had executed to gather information related to the Yeghvard Irrigation Project (hereinafter referred to as "the Project") by sending the contact missions as well as sending questionnaire in order to formulate the Project.

2) Based on the information that JICA obtained through the above 1), JICA proposed two-phased studies; a) Pre-feasibility Study (Concept Review) and b) Full-scaled Feasibility Study (F/S), and the Government of RA agreed the above mentioned proposal.

3) Then, JICA dispatched the Survey Team as place of the above a) Pre-feasibility Study in June 2014.

4) The Survey Team conducted a field survey including of data/information collection and had a series of discussions with related agencies in the RA from June through August 2014, and analyzed the collected information prior to prepare the DFR in Japan during September to October 2014.

2. Summaries of the explanatory discussions for the DFR

The Mission and the Survey Team explained the contents of DFR to State Committee for Water System (SCWS), Ministry of Territorial Administration and the agencies concerned to the Survey on November 4, then the Survey Team explained to the Water Sector Projects Implementation Unit (PIU) on November 5, 2014. Participants are listed in the Attachment. Main discussions done during explanation of the DFR are summarized as bellow;

2-1. For SCWS and other related ministries held on November 4, 2014

1) The Armenian side in principle accepted the contents of DFR.
2) The Armenian side suggested that application of water saving-irrigation technique to the project should be examined during the full-scaled F/S as one of the important project assumptions in order to reach appropriate designed reservoir capacity.
3) The Survey Team indicated a tentative schedule and task of the full-scaled F/S from April in 2015 to February in 2016 in their presentation. The Mission added that the implementation of F/S should require the approval process of JICA board meeting and the Ministry of Foreign Affairs of Japan before starting the F/S.
4) The Mission requested the Armenian side to give comments on the DFR by the end of November. The Armenia side agreed it.
5) At the end, the Mission stated that procurement procedure of the consultants for the full-scaled F/S in the next step should be executed by JICA headquarter in Japan before the commencement of the F/S. The Armenian side understood it.

2-2. For PIU and Armvod Project Institute held on November 5, 2014

The Survey Team presented approx. 80 numbers of slides as place of summary of the DFR. The Armenian side in principle accepted the contents of DFR. Suggestions from the Armenian side and discussions are summarized below;

1) Since some figures such of planned irrigation area, project cost for Kaps and Vedi projects, indicated in the table for "comparison of the outline of 3 projects" are found slightly wrong, the PIU will correct them through the comment to be given by the end of November.
2) Concerning consumption volume 50MCM/year of the Lake Sevan to be expected saved after the Project implementation, PIU gave a consultation; while the rehabilitation works of "Vorotan→Arpa tunnel" has already been completed, water level of the Lake Sevan would be recovered till full level of its original capacity before year 2037.
3) Related to the above 2), an engineer from Armvod suggested following original shape of proposed reservoir, i.e. 228MCM of capacity without reducing area of reservoir basin. So that surplus water to be brought from the Lake Sevan would be retained in the proposed Yeghvard reservoir prior to the future preparation.

   The Survey Team pointed out that the request from the government of RA as of 2012, of which reservoir capacity was 90MCM. And in consideration with issues on high permeability of geological condition at the reservoir basin, the F/S should be carried out and examined in the basis of 90-110MCM. And finally both PIU and the Survey Team agreed to confirm it by further discussion in the F/S.
4) Concerning one of the alternative; "Soil-cement coating method" for anti-filtration work to reservoir basin, the Survey Team asked to PIU availability of their experience for laboratory test of hexavalent chromium liquation in the RA. The PIU answered it has not been available in the RA so far.

   On the other hand, PIU recommended to utilize the Bentonite sheets for the coating method because a factory of it would be built in near future in the RA, which would expect being cheaper materials rather than others. Both Armenian and the Survey Team

sides confirmed this matter should be carefully considered during the F/S to make the Project feasible.

5) The PIU asked the Survey Team a possibility to combine two(2) tasks, namely; F/S and following detail design, taking into consideration their traceability.

   The Survey Team replied that current JICA procurement system would not allow it, however, promised to convey this suggestion to JICA headquarters.

6) At section of “Environmental & Social Assessment Procedure”, PIU clarified the meaning of “undertaker” as consultants.

   The Survey Team stated that it might not be accepted by JICA; the loan recipient country should have a responsibility on it with the assistance of consultants according to current JICA guideline. Also, the Survey Team suggested to the PIU discussing with JICA before starting the F/S.

津村和光

Kazumitsu TSUMURA
Chief Consultants,
JICA Survey Team,
Sanyu Consultants Inc. (SCI)

(Attachment)

List of Participants (1/2)

1. For SCWS and other related ministries held on November 4, 2014

State Committee for Water System (SCWS), Ministry of Territorial Administration

1.	Vahe Hakobyan	Chairman, SCWS
2.	Ashot Mardyan	Deputy Chairman, SCWS
3.	Mher Mkrtumyan	Head of Staff, SCWS
4.	Tigran Khachikyan	Head of Finance Department, SCWS
5.	Felix Melikyan	Director, PIU
6.	Karen Grigoryan	Deputy Director, PIU
7.	Khoren Tsarukyan	Engineer, PIU

Related Ministries

1.	Artur Baghdasaryan	Head of Department of Land Use and Reclamation, Ministry of Agriculture
2.	Susanna Iskandaryan	Senior Expert, International Cooperation Department, Ministry of Finance
3.	Artyom Khachatryan	Second Secretary, Ministry of Foreign Affairs

Japan International Cooperation Agency (JICA)

1.	Tetsuya Yamada	Director, JICA
2.	Hiroaki Adachi	Assistant Director, JICA
3.	Ruzan Khojikyan	Program Coordinator, JICA Armenia Liaison Office

JICA Survey Team

1.	Kazumitsu Tsumura	Team Leader (Consultant)
2.	Fusataka Arakawa	Co-team Leader, Irrigation
3.	Harunobu Yoshino	Agronomist
4.	Haruo Hiki	Dam Engineer
5.	Tatevik Minasyan	Assistant / Interpreter
6.	Kristine Goroyan	Assistant / Interpreter
7.	Arevik Danielyan	Assistant / Interpreter

List of Participants (2/2)

2. For PIU and Armvod Project Institute held on November 5, 2014

Project Implementation Unit (PIU)

1.	Karen Grigoryan	Vice Director
2.	Morzpet Tonoyan	Engineer
3.	Hamlet Harutyunyan	Engineer
4.	Edik Gndolyan	Engineer
5.	Marine Vardanyan	Sociologist
6.	Gayane Karimyan	Lawyer
7.	Martiros Nalbandyan	Environmental Specialist
8.	Suren Tovmasyan	Geodesist
9.	Tigran Ishxanayan	Director of WUA's Support Team
10.	Ara Hovhannissyan	Financial Management specialist
11.	Varazdat Mkrtchyan	Engineer
12.	Ara Grigoryan	Engineer
13.	Khoren Tsarukyan	Engineer

Armvod Project Institute (Hayjrpetnaxagits)

1.	Gagik Ghazaryan	Chief Engineer
2.	Tarverdian A.	Engineer

JICA Survey Team

1.	Kazumitsu Tsumura	Team Leader (Consultant)
2.	Fusataka Arakawa	Co-team Leader, Irrigation Engineer
3.	Harunobu Yoshino	Agronomist
4.	Haruo Hiki	Dam Engineer
5.	Tatevik Minasyan	Assistant / Interpreter
6.	Kristine Goroyan	Assistant / Interpreter
7.	Arevik Danielyan	Assistant / Interpreter

Համաշխարհային բանկ
ՀՀ տարածքային կառավարման նախարարության
Ջրային տնտեսության պետական կոմիտեի
<<Ջրային տնտեսության ծրագրերի իրականացման գրասենյակ>> պետական հիմնարկ

World Bank,
State Committee of Water Economy under the RA Ministry of Territorial Administration
"Water Sector Projects Implementation Unit"
State Institution

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JICA Armenia Liaison Office

Dear Khojikyan Ruzan

First of all, we would like to express our gratitude to Japan International Cooperation Agency (JICA) for cooperation and implementation of Pre-feasibility Study of Yeghvard Irrigation Project, as well we want to thank Sanyu Consultant team for carrying out such a large amount of work on detailed Feasibility Study and Analysis. We hope to go on cooperating with the Consultant Team in further phases of the project.

The Draft Final Report of the Data Collection Survey on Agriculture and Irrigation Sectors in related to Yeghvard Irrigation Project in the Republic of Armenia was presented on November 2-6 2014 in Armenia by the head of State Committee for Water System (SCWS) President Vahe Hakobyan and by Tetsuya YAMADA, Director of Central Asia and the Caucasus Division, East and Central Asia and the Caucasus Department

The Consultant Team headed by Kazumitsu TSUMURA *presented the* Draft Final Report of The Data Collection Survey on Agriculture and Irrigation Sectors in related to Yeghvard Irrigation Project in the Republic Of Armenia.

Parties came to an agreement, that the Armenian side will give comments on DFR by the end of November.

On the whole we approve the highlighted problems for the project implementation and its solution methodology, and simultaneously we propose:

1. In the section "Project Costs and Financial Analysis" a table for comparison of Vedi and Kaps project was presented there were some inaccuracies. PIU reviewed those data to the final results. The data is presented in the tabel below.

Project	Dam /Reservoir			Agriculture		Irrigation		Cost Million
	Dam height (m)	Volume (MCM)	Reservoir surface area (000m²)	Planned main crop (Major→Minor)	Planned water demand (MCM/y) (Saving irrigation %)	Existing pumped area	Planned irrigation area (ha)	
Kaps (KfW)	55m	25MCM	Approx 1,300	1)Wheat 2)Barley 3)Potato 4)Maize 5)Vegetable	Approx. 25MCM (Saving Irrigation: S.I.100%)	2,148ha	19,240ha	60M.EURO + 22.5 M.EURO
Vedi (AFD)	72.5	29MCM	Approx. 1,400	1)Vegetable 2)Fruit, 3)Grape, 4)Wheat, 5)Fodder	32MCM (S.I.50%)	2,440	2,820ha	90 M.EURO
Yeghvard	30-35m	90-110 MCM	Approx. 8,400	1)Wheat, 2)Vegetable 3)Grape, 4)Fruit, 5)Fodder	148MCM (S.I. 0%)	9,200	12,200ha	

2. Taking into consideration the filtration losses from the reservoir basin, the Consultant Team suggests to reduce the area of the reservoir basin from 840 ha to 600 ha by building new dams. This issue will be discussed with the Consultant team in further phases of the project.

3. Yeghvard reservoir preliminary version of the volume of 90 million m³, but the hydraulic calculations results made by the consultant team show that it is possible to increase the

   volume of the reservoir up to 110 million m³. As a result it is possible to accumulate a surplus of 20 million m³ of water per year. PIU approves this option. This issue will also be discussed in further stages of the project.

4. To reduce Reservoir filtration flow, the Consultant Team proposed to conduct anti-filtration activities using 6 different sorts of material. PIU suggests to use Bentonite sheets for the coating method because in near future a factory of Bentonite would be built in the RA, which means that it will be cheaper material rather than the others. This issue will also be discussed in further stages of the project.

5. What regards the Environmental and Social Impact Assessment (ESIA) process, the PIU wishes to acknowledge that this issue was discussed during the previous meetings as well. Earlier the Consultant insisted that ESIA report for the project should be developed by PIU. However, the PIU environmentalist objected on the grounds that preparation of ESIA requires involvement of a firm with specialized experienced staff. As a state institution, the PIU should ensure elaboration of the ESIA (of course, if the PIU will be assigned with such task) instead of preparation. We want to re-affirm this point once again.

   What regards the initiator of such activities, the sub-clause 17, clause 1, Article 4 of the Law of the RA on "ESIA and Expert Examination" defines the notion "Initiator" according to which "Initiator" means any state or local authority, any legal or physical entity, which develops the fundamental document subject to expert examination, orders, accepts such document or executes it.

   Based on this formulation, the PIU thinks that ESIA for the Project may be developed by the Consultant or through the future loan funds. In latter case the PIU will assign ESIA preparation to a local or international experienced firm.

   What regards the submission of ESIA report for expert examination, it should be noted that the entire design shall be submitted to expert examination, part of which is the ESIA, instead separate expert examination of the ESIA report only. Therefore it would be logic if the author of the design be also initiator of the expert examination, i.e. the consultant (even if ESIA is developed by another firm).

It's also important to consider international and RA norms and standards for the design, construction, operation and maintenance of the reservoir in the F/S phase.

All the issues related to Yeghvard Irrigation Project will be thoroughly studied and discussed in the F/S.

Sincerely yours,

Felix Meliqyan

Acting director,

Water Sector Projects Implementation Unit

The Republic of Armenia (RA)
State Committee of Water Economy

Data Collection Survey on Agriculture and Irrigation Sector

(for the Yeghvard Irrigation Project)

Draft Final Report (DFR)

November 04, 2014

Japan International Cooperation Agency (JICA)

Sanyu Consultants Inc. (SCI)

1

Contents

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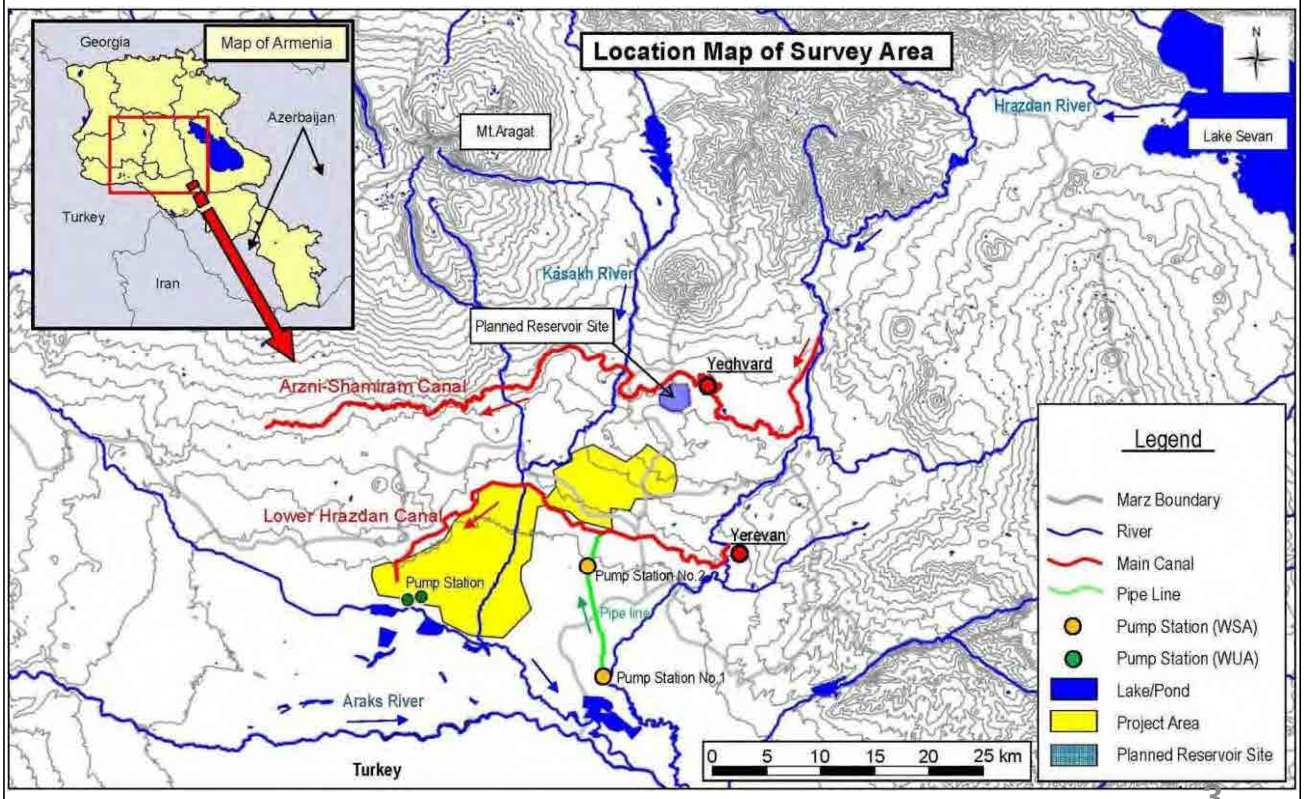
The Survey Area



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1. Background and objectives (1/2)

1. The government of Japan has responded to the request of Armenia for the Japanese ODA loan and dispatched the JICA contact mission in relation with the Yeghvard Irrigation Project in February 2014.
2. Through the investigations in Armenia, it was found that the construction of reservoir which had been designed with a capacity 228 MCM at the time of USSR was started at early 1980s and suspended in 1985 due to a financial deficit, and after such history of construction the capacity was reduced to 90 MCM from 228 MCM in 1999.

4

1. Background and objectives (2/2)

3. Based on a series of discussions with Armenian officials, JICA has judged to study/examine the possibility of the re-use of embankments, geological /hydrogeological conditions, hydrological information, farming status, target irrigation area in Yeghvard and the designed capacity of the reservoir and so on.
4. In this survey, collection of data/information on the current state of the agriculture and irrigation sectors in RA related to the Yeghvard Irrigation Development Project was carried out in order to examine the possibility of a Japanese ODA Loan.

2. National development policies related to Water resources / Irrigation and Agriculture sectors in RA (1/3)

2-1. Armenia Development Strategy (ADS) for 2014 – 2025;

1. To invest 0.3% of the GDP for irrigation development,
2. To extend irrigated land areas and improve irrigation efficiency of existing irrigated lands,
3. To improve collecting irrigation tariff by financial support of WUAs and
4. To strengthen already formed participatory management and so on.

2. National development policies related to Water resources / Irrigation and Agriculture sectors in RA (2/3)

2-3. Sustainable Agricultural Development Strategy (SADS) for 2010 – 2020;

<Main goals>

1) To promote industrialization of agriculture (value-addition)
2) To increase the food security level, and
3) To shape favorable conditions for promoting export-oriented products.

<Related to agricultural infrastructure>

1) To improve the irrigation system,
2) To enhance the operation and maintenance (O&M),
3) To establish the Water Users Associations (WUAs) / enhance existing WUAs, and
4) To change irrigation system to gravity from pump.

3. Water utilization of the Lake Sevan (1/4)

National Water Policy (2005) has placed "the water resources conservation" for the top-most priority, then the following priorities are;

1. Tradition/custom, 2. International laws,
3. What is essential for the nation,
4. Agriculture (irrigation / livestock),
5. Energy, 6. Industry, 7. Recreation, and
8. Measures during drought periods.

National Water Program (2006) has listed the followings;

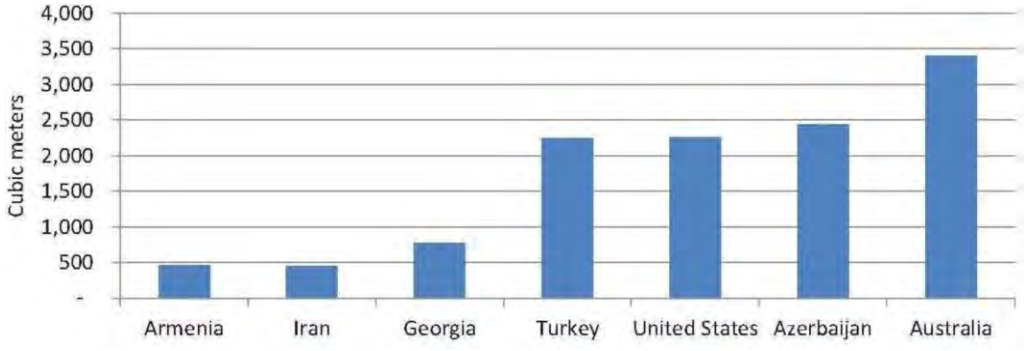
1. Promoting a subsidized assistance policy for the WUA,
2. Shifting irrigation system from pump to gravity (saving O/M cost),
3. consolidating irrigation infrastructure and introducing modern irrigation techniques,
4. Improving O/M efficiency by means of rehabilitating irrigation system,
5. initiating participatory water management by the WUA, and
6. Expanding the irrigated farmland area.

3. Water utilization of the Lake Sevan (2/4)

3-2. Water resources

1) Medium and small scaled reservoirs have been constructed during Soviet time.
2) New reservoir such as Marmarik was constructed in 2012.
3) Planning of constructing reservoirs are still on-going.

However, the storage capacity of reservoirs storage facilities per capita in Armenia is smaller.



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3. Water utilization of the Lake Sevan (3/4)

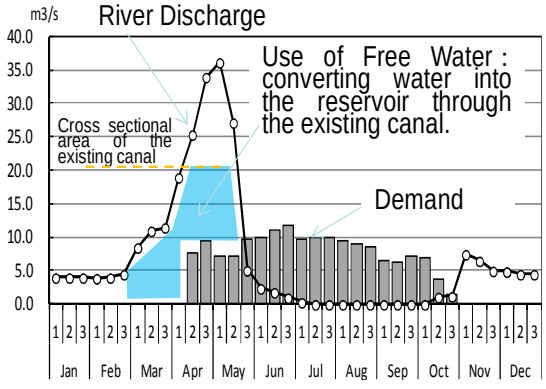
3-3. Irrigation policies

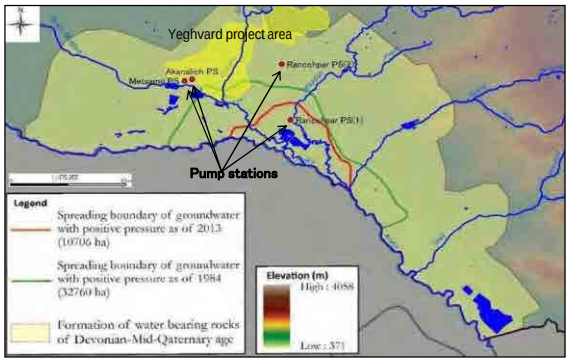
(1)Policy away from Energy Intensive Agriculture

Converting irrigation methods from pump-dependent to gravity based irrigation.

(2)Countermeasures for groundwater level's draw down

Shift from dependence on groundwater to effective use of surface water for irrigation.

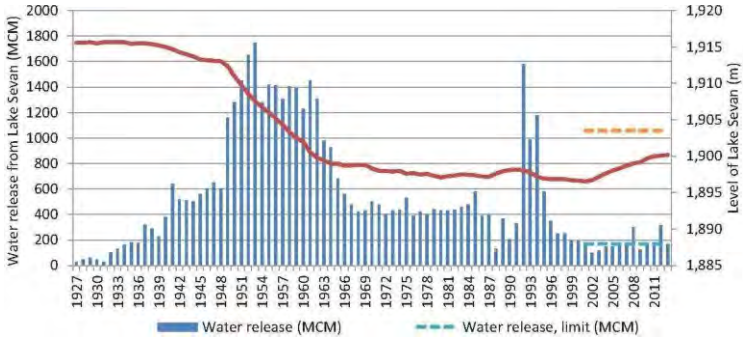




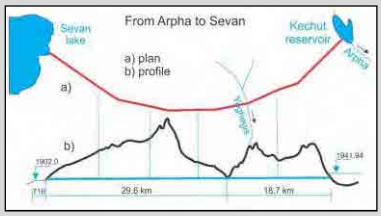
3. Water utilization of the Lake Sevan (4/4)

3-4. Water resource use in Lake Sevan

1) The largest water storage capacity in the country,
2) The tunnels as conservation measures of Lake Sevan,
3) The upper limit of annual releasing water (170MCM),
4) Consideration of watershed management cooperate with river basin.



Increase the withdrawal from Lake Sevan in 2014
170MCM (Base value) ==> up to 240 MCM (January)
==> up to 270 MCM (August) by government of RA.



Month (2010)	Discharge (MCM)	Month (2010)	Discharge (MCM)
Jan	18.0	Jul	16.9
Feb	17.9	Aug	9.5
Mar	35.4	Sep	4.1
Apr	40.4	Oct	4.2
May	42.6	Nov	3.9
Jun	40.2	Dec	4.1
		Total	237.2

4. Main findings on agricultural status in RA (1/4)

4-1. From SADS

Year	2007	2020	±%	2007	2020	±%
Cereals	176.2	190.0	107.8	452.5	665.0	147.0
Potatoes	31.6	30.0	94.9	583.9	750.0	128.4
Vegetables/Melons	31.5	31.0	98.4	1,051.6	1,357.5	129.1
Forage crops	65.0	155.0	**238.5**	-	-	-
Industrial crops	1.6	15.0	**937.6**	-	-	-
Fruits/Grapes	53.9	86.2	159.9	479.1	1,037.5	**216.6**

Year	2007	2020	±%	2007	2020	±%
Cattle (beef)	629.1	667.0	106.0	78.6	97.0	123.4
Cows(milk)	310.6	328.5	105.8	598.9	850.5	142.0
Pigs (Pork)	86.7	210.0	**242.2**	20.4	24.0	117.6
Sheep & Goats (Mutton)	637.1	1,550.0	**243.3**	15.5	46.5	**300.0**
Sheep & Goats (Milk)	-	-	-	42.3	123.7	**292.4**
Sheep & Goats (Wool)	-	-	-	1,277.0	3,560.0	**278.8**
Poultry (Meat)	4,018.2	8,000.0	199.1	7.8	16.0	**205.1**
Poultry (Egg)	-	-	-	545.4	750.0	137.5
				Mil. Pcs	Mil. pcs	

4. Main findings on agricultural status in RA (2/4)

4-2. Food Security

1. Per capita calorie supply in recent years: about 2,800 kcal/day (sufficient amount of food is supplied at a national level)
2. The supply from vegetable products: decreasing since 2006
3. The supply from animal products: increasing gradually

<Self-sufficiency (%) of major Foods>

Food	2010	2011	2012	Food	2010	2011	2012
Wheat	33.5	36.5	32.9	Sugar	24.6	43.9	93.1
Maize	20.8	26.5	32.6	**Eggs**	**99.2**	**94.1**	**99.5**
Potato	**100.2**	**98.2**	**99.0**	Milk	87.0	82.9	83.1
Vegetables	**98.3**	**98.2**	**99.3**	Beef	85.1	78.4	81.6
Fruits	**79.8**	**90.0**	**96.1**	Pork	41.1	43.3	38.3
Grapes	**101.1**	**101.4**	**102.6**	**Mutton/lamb**	**100.0**	**100.0**	**100.0**
Legumes	41.7	47.3	56.0	Chicken meat	12.4	12.4	12.4
Vegetable oil	4.1	2.8	9.1	***(Source: The Ministry of Agriculture, RA)***			

4. Main findings on agricultural status in RA (3/4)

4-3. Foreign Trade of Agricultural Products (1/2)

<Imports & Exports>

1. Many foods are imported every year (see the table in previous page), beside there are very limited amount of exported agricultural products
2. Wheat, a major staple food, and maize are major imported products
3. While sugar was the second largest imported commodity, the self-sufficiency rate has been increased at more than 90% in 2012
4. Meats, except for mutton & lamb, are also considerable imported commodities. Among meats, poultry meat is the most imported
5. Fruits including wine and brandy are the most exported products, however a substantial amount of tropical & sub-tropical fruits are imported
6. Vegetables are also important exported products. As same as fruits, a substantial amount of vegetables also imported mainly in winter season.

4. Main findings on agricultural status in RA (4/4)

4-3. Foreign Trade of Agricultural Products (2/2)

<Competitiveness of the Armenian Products> (fresh and processed)

1. Fruits and some vegetables still have a competitiveness in Russia and CIS countries, through there are several strong competitors
2. There are a number of challenges to tackle strict regulations, food hygiene standards, stable supply of diverse products, etc. to enter the EU market.

5. Main findings on agricultural status in Yeghvard (1/5)

5-1. WUAs

WUA	Commu-nities	WUA Mem-bers	Farm-land (ha)	Irrigated 2013 (ha)	Irrigated (%)	Ave. Irrigated Land (ha)
Yeghvard	3	1,194	2,428	1,050.4	43.3	0.88
Ashtarak	4	1,716	1,739	916.0	52.7	0.53
Vagarshapat	3	878	639	605.0	94.7	0.69
Khoy	13	5,378	5,236	5,093.0	93.7	0.95
Aknalich	4	2,013	2,158	1,556.0	72.1	0.77
Total	**27**	**11,179**	**12,200**	**9,220.4**	**75.6**	**0.82**

Source: PIU, the State Committee for Water System

5. Main findings on agricultural status in Yeghvard (2/5)

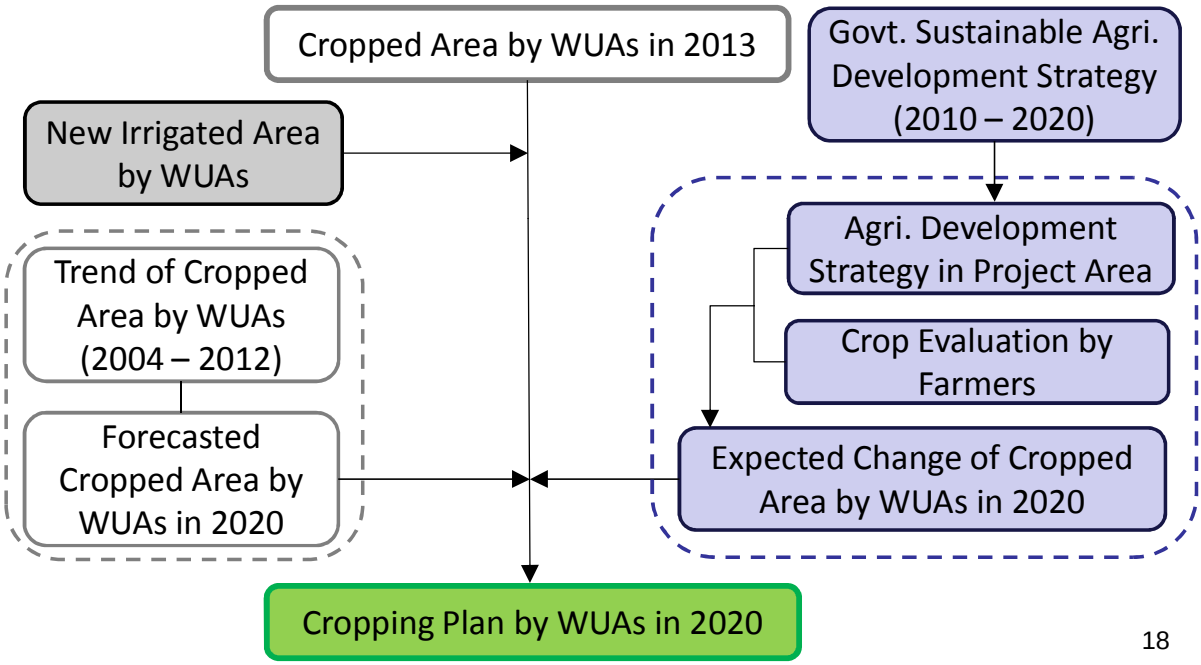
5-2. Farmers' problems (Output of WUA workshops)

1. Lack of technical consultancy services & Govt. support
2. High production costs
3. Low quality of agri. inputs
4. Degradation of soil fertility
5. Lack of farm machinery
6. **Lack of irrigation water and degradation of water quality**
7. Lack of accessible Agri. Credit
8. Natural disaster
9. **Marketing (low price, no good buyers & poor road condition)**

5. Main findings on agricultural status in Yeghvard (3/5)

5-3. Agricultural Development Plan (1/2)

<Planning Procedure>



5. Main findings on agricultural status in Yeghvard (4/5)

5-3. Agricultural Development Plan (2/2)

<Cropping Plan by WUAs in 2020 (Suggested*)

WUA		Cropped Area by Crops (ha)						
		Wheat	Vegeta-bles	Grape	Orchard	Perennial grass	Others**	**Total**
1	Yeghvard	500	100	250	650	480	448	2,428
2	Ashtarak	140	80	550	300	210	459	1,739
3	Vagarshapat	295	165	40	55	25	59	639
4	Khoy	1,300	1,200	850	550	350	986	5,236
5	Aknalich	500	700	120	25	275	538	2,158
	Total (%)	**2,735 (22.4)**	**2,245 (18.4)**	**1,810 (14.8)**	**1,580 (13.0)**	**1,340 (11.0)**	**2,490 (20.4)**	**12,200 (100)**

Note: * Farmers have a free hand to choose crops in accordance with farming condition
**** Potato, barley, maize, etc.**

5. Main findings on agricultural status in Yeghvard (5/5)

5-4. Export Promotion Strategy

1. Target markets = to diversify the markets
- Short-term: Russia & other CIS countries (keep and expand the present markets)
- Mid/Long-term: EU countries (develop new markets)

→Need to produce hygiene (safety & security) products

2. Target crops/products
- Vegetables (Short-term)
- Fruits & Grape, including brandy & wine (Short-term)
- Flowers & Ornament plants (Mid/Long-term)
- Sheep (Live animals to Iran)
- Meat (Mid/Long-term)

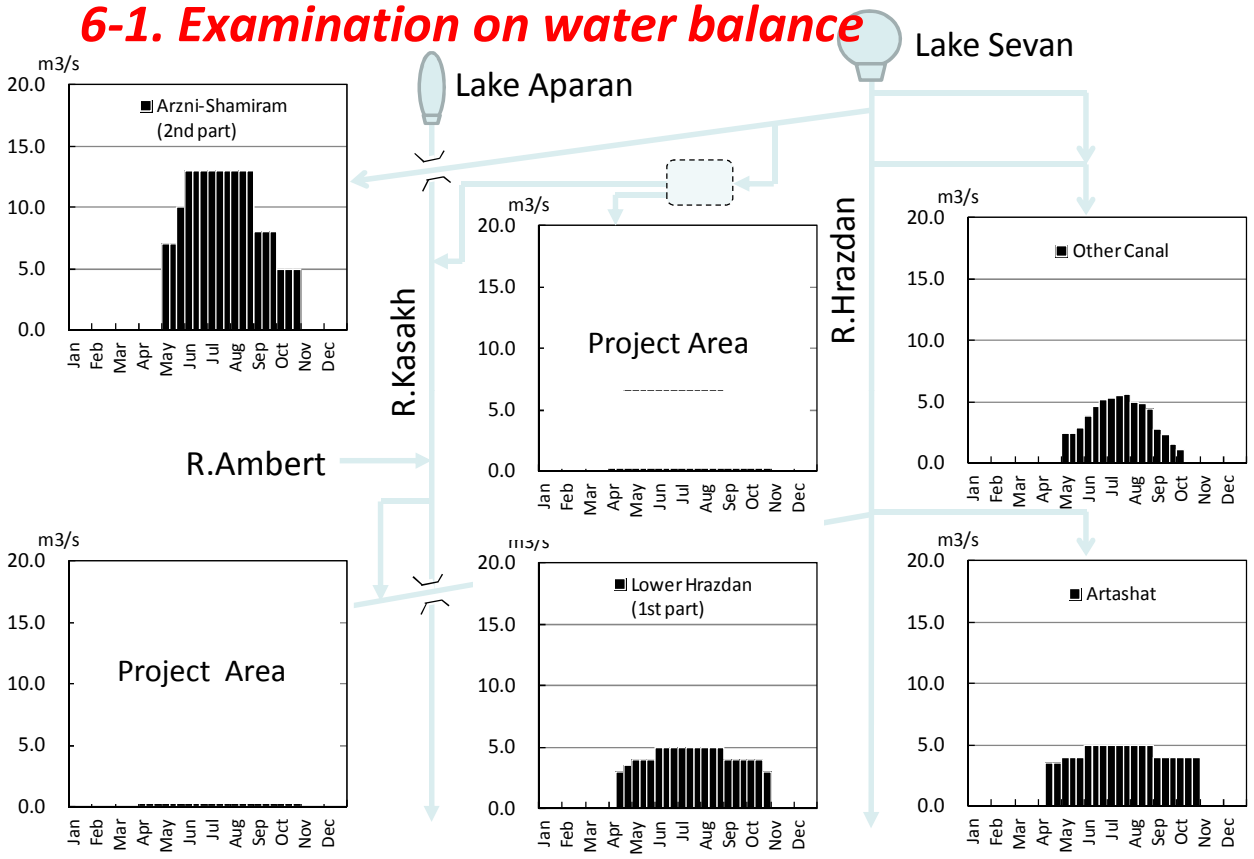
→Need to fulfill domestic demand for the short-term

3. Agri-business development
- Cold chain system (transportation & storage)
- Hygiene-oriented marketing & processing (Mid/Long-term)

→Need to develop hygiene control system for domestic market for the short-term

6. Irrigation planning of Yeghvard reservoir (1/5)

6-1. Examination on water balance



6. Irrigation planning of Yeghvard reservoir (2/5)

6-2. Pre-conditions and Irrigation norm

Irrigation Area (except Project Area)	Demand *) (precondition)
Arzni-shamiram (2nd part)	159.1 MCM
Lower Hrazdan (1st part)	76.2 MCM
Artashat	77.6 MCM
Other canal	52.6 MCM
Total	365.5 MCM

*) Conveyance loss is included (Demand data was provided from PIU.)

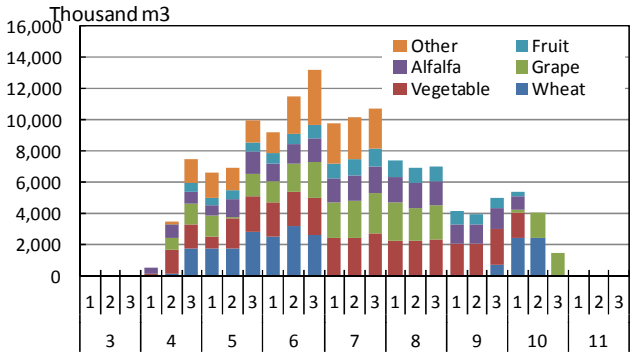
Crop	Water Volume	Irrigation Times	Total (m^3/ha)
Wheat	950	4	3,800
Vegetables	650	13	8,450
Grape	900	8	7,200
Alfalfa	900	9	8,100
Orchard (Fruit)	500	8	4,000
Maize (other)	800	5	4,000

Note: Demand is calculated refer to " Armavir Marz, heavy sand type, The norms and regime of the irrigation of agricultural crops for irrigated areas in Armenia".

6. Irrigation planning of Yeghvard reservoir (3/5)

6-3. Water demand and other Pre-condition

Crop	Area (ha)
Wheat	2,735
Vegetables	2,245
Grape	1,810
Alfalfa	1,340
Orchard (Fruit)	1,580
Other	2,490
Total	12,200



Demand = 145.0 MCM

Note: Demand is calculated refer to " Armavir Marz, heavy sand type, The norms and regime of the irrigation of agricultural crops for irrigated areas in Armenia".

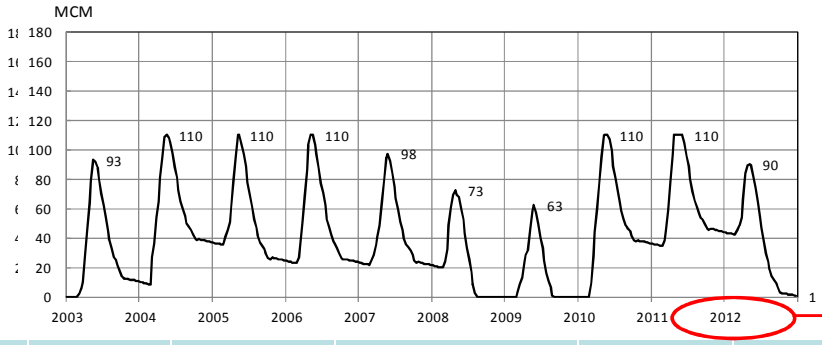
Canal	Conveyance Efficiency
Main Canal	72 %
After Secondary Canal	65 %
Total	46.8 %

Item	Description
Evaporation 1)	0.36 MCM/month
Infiltration 2)	0.61MCM/month

1) Yeghvard observation point (Average value)
2) Highest value refer from F/S Report's caluculation (Armvodproject)

6. Irrigation planning of Yeghvard reservoir (4/5)

6-4. Water balance calculation

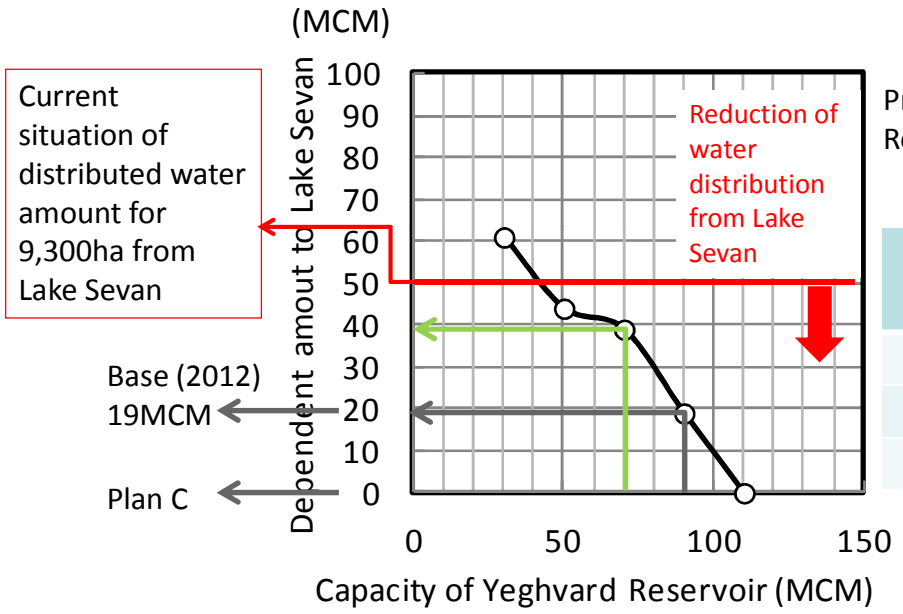


< 2012 >
R.P. = 4year
(75% Probability)

Plan	Demand (MCM)	Yeghvard (MCM)	Lake Sevan (MCM)		Hrazdan River (MCM)	Countermeasure to Deficiency of project area	Conveyance Efficiency (%)
			Others	Project			
Base (2012)	145.0	90	188	**19**	196	Lake Sevan	46.8 %
A	145.0	90	188	0	196	**Rancchabar P/S**	46.8 %
B	145.0	**110**	188	0	196	Increment of Reservoir	46.8 %
C	133.1	90	188	0	196	Rehabil. of Canal System	**51.0 %**

6. Irrigation planning of Yeghvard reservoir (5/5)

6-5. Relationship between capacity of Yeghvard Reservoir and distributed water from Lake Sevan



Project Area : 12,200ha
Return Period : 1/4

Yeghvard (MCM)	Sevan (MCM)	
	Project	Others
110	0	188
90	19	188
70	39	188

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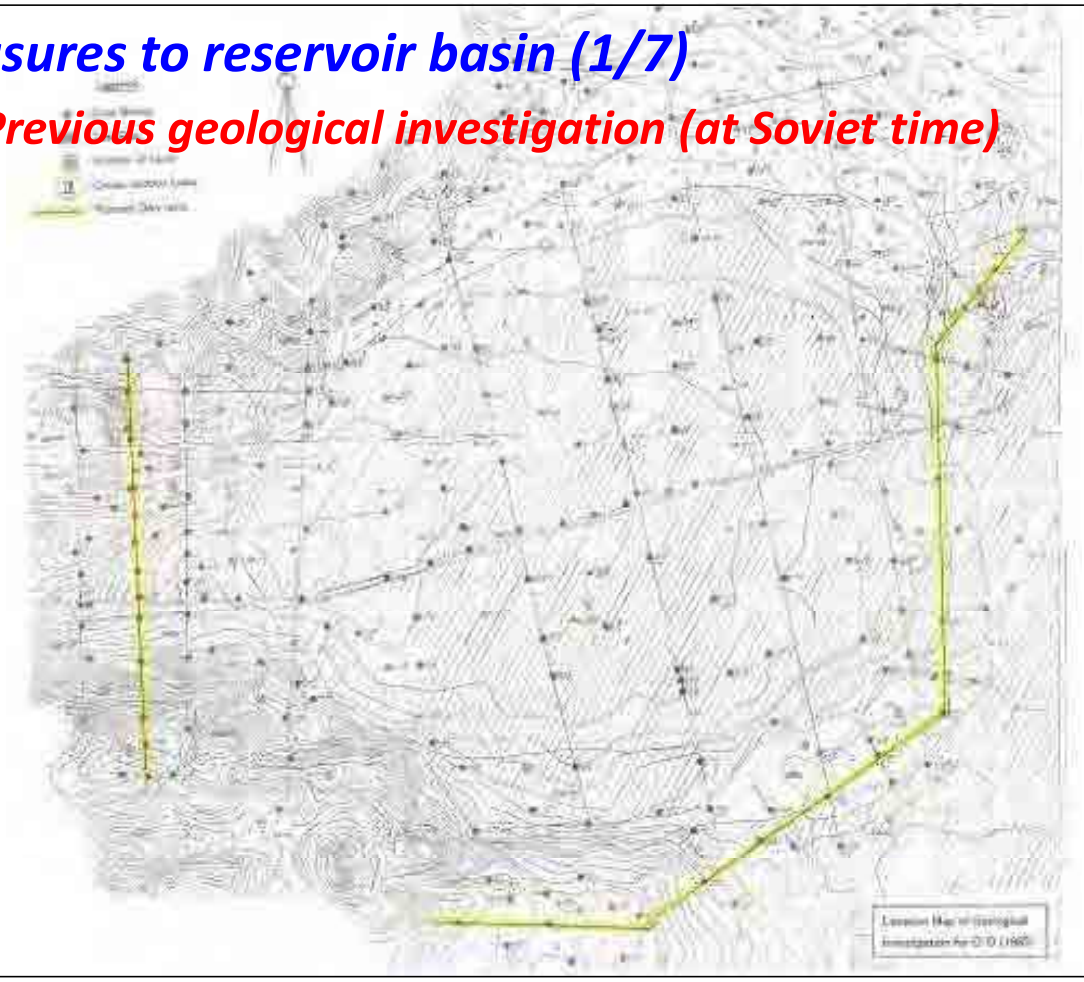
7. Measures to reservoir basin (1/7)

7-1. Previous geological investigation (at Soviet time)



7. Measures to reservoir basin (1/7)

7-1. Previous geological investigation (at Soviet time)

1) The first geological investigation on the Yeghvard basin under a concept of Yeghvard reservoir plan was carried out in 1931.
2) In 1979, a systematic geological investigation for F/S on Yeghvard Reservoir was conducted, and
3) From 1983 to 1984 another systematic geological and geophysical investigation were conducted for Detail Design Study (D/D) on the reservoir plan.
4) During these study periods, huge amount of geological investigation, geophysical prospecting, and soil laboratory tests were carried out.
5) The figure shows geological map of the reservoir area, and locations of geological and geophysical investigation work in the D/D period
6) Red circles are core-boring points, blue square points are test-pits, and straight lines are geophysical prospecting lines.

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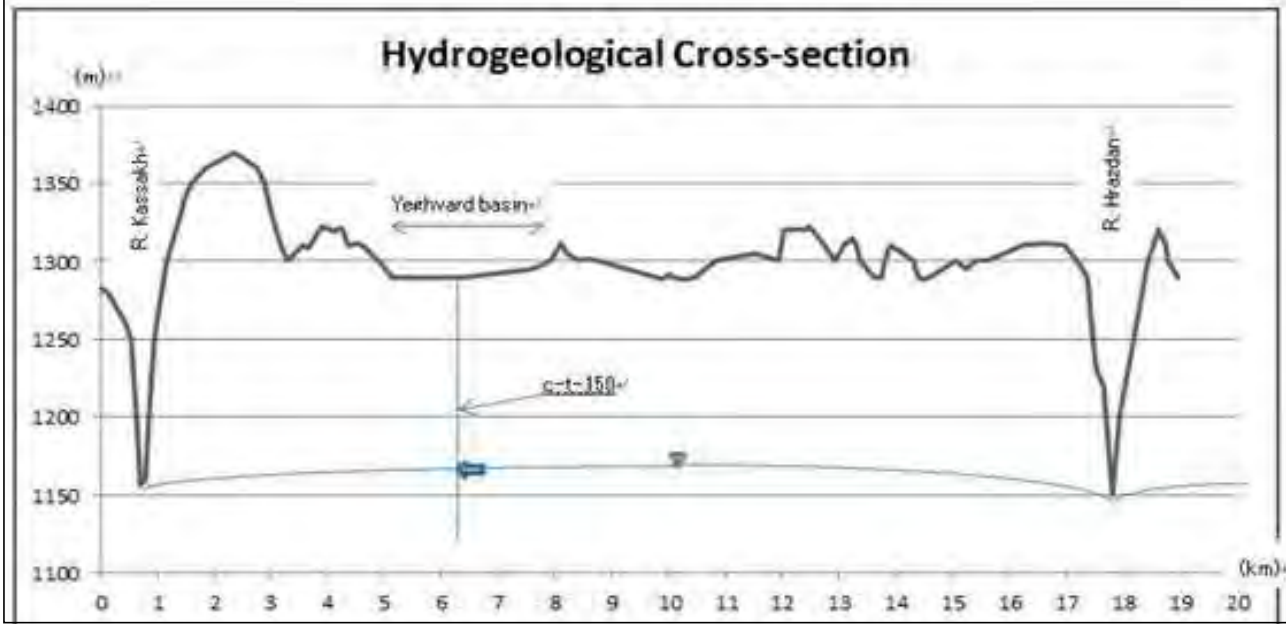
7-2. Hydro-geological condition of Yeghvard area (2/7)



7. Measures of reservoir basin (2/7)

7-2. Hydro-geological condition of Yeghvard area (1/2)

1) Topographically, the Yeghvard basin is located in typical "interfluve zone", being cut its EW sides by the Kasakh and the Hrazdan rivers.
2) The hydro-geological condition of the Yeghvard basin is quite simple; composed of the Miocene sediments as an "impervious basement", and volcanogenic formations and unconsolidated sediments from Pliocene to Resent as a "pervious over cover".
3) In the Yeghvard basin, there is no permanent river flow and no perennial pond, and it means rain water supplied in the reservoir area is immediately infiltrated into the ground. Depth of the impervious basement is more than 210m depth from the ground surface, suggesting that it is very difficult to form a groundwater aquifer in this area.

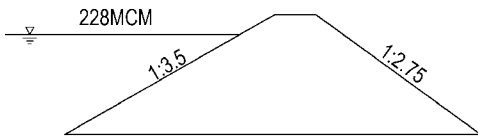
7. Measures of reservoir basin (2/7)

7-2. Hydro-geological condition of Yeghvard area (2/2)

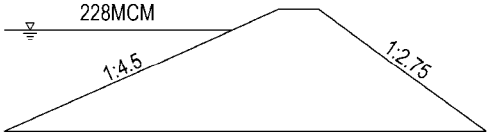
4) Throughout the Russian geological survey in the damsite, only two borehole detected groundwater table at the depths of 91.5 and 120.5m. The nearest permanent river flow is the Kasakh river flowing about 5.2km west of the dam site forming a deep canyon, and the next is the Hrazdan river flowing SW direction around 12km east, also forming a great canyon.
5) Water level of the Kasakh is 1,156m and the Hrazdan's one is around 1,150m, then, the groundwater levels found in the reservoir area are 1,199 and 1,169m, as shown in the figure.
6) Groundwater table shall be very flat, and it means the permeability of the formations consisting the reservoir area is quite pervious.

7-3. Reservoir construction plan

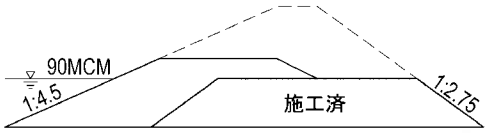
Original Plan in 1983



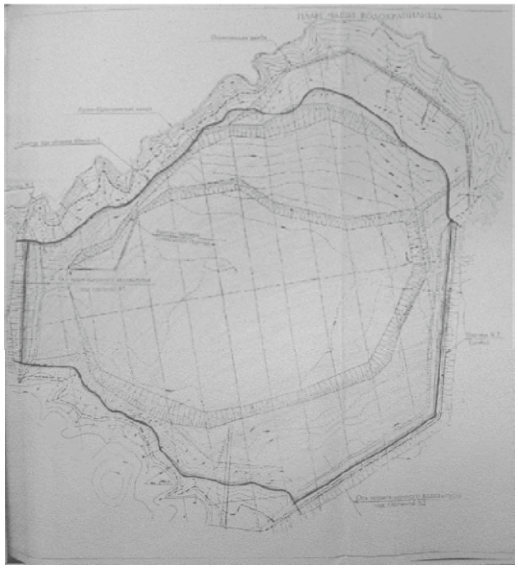
Modified Plan in 1989 after Spitak Eq.



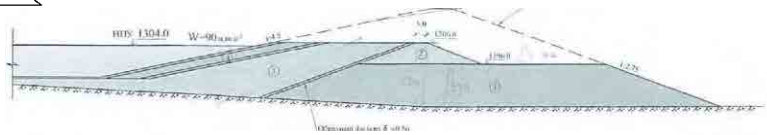
Revised Plan in F/S, 1999



Proposed Plan at this stage based on F/S



Plane view of the reservoir



Dam cross-section (Dam No.1)

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7-4. Dam location plan considering the utilization of the existing embankments

Conditions of the existing embankments ➡ Utilizable as a part of dam body

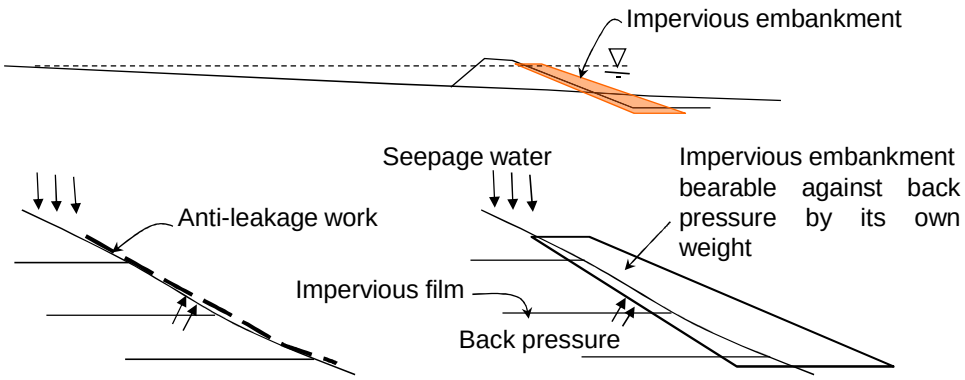
Utilization plan

Basic;

Inclined core zone connected with the anti-leakage works on the reservoir bottom

Planar plan;

1) Rectangle shape with the longer axis connecting Dam No.1 and Dam No.2
2) Closing the eastern and western ends of the basin by Dam No.1 and Dam No.2
3) Cut-slope formation or a cut-and-bank formation on northern/southern ends to avoid the water surface extension and decrease the area of anti-leakage work to prevent the back pressure from making the anti-leakage work unstable



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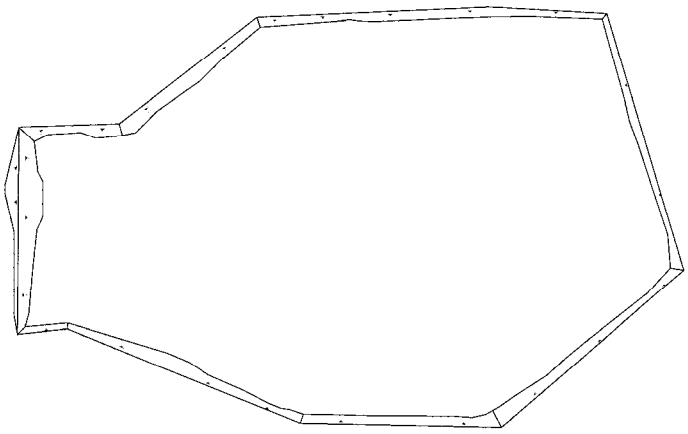
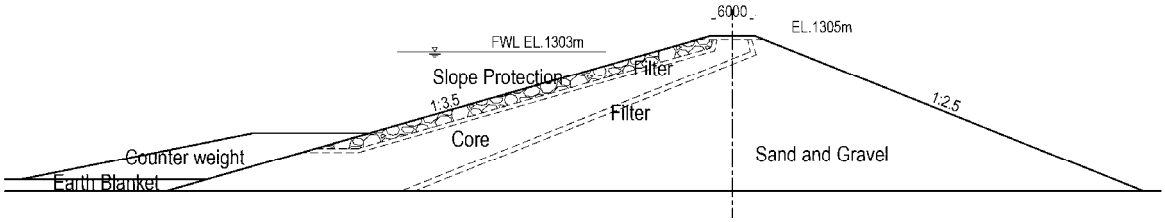
7. Measures to reservoir basin (5/7)



Planar plan of Yeghvard Reservoir (basic image)



Cross-section of dam body (basic image)

7-6. Anti-infiltration work to reservoir bottom (1/2)

i) Earth blanket coverage method

Cover the reservoir bottom by the earth blanket, spread and compacted soil layer.

Expectable k=5 × 10^{-6}cm/sec is not enough to reduce the leakage from such a wide area.

ii) Watertight asphalt concrete coating method

Pavement of watertight asphalt concrete covering the reservoir bottom.

Popular as the leakage control work of the fill-type dam with facing.

Construction cost of 150 USD/m2 is too expensive.

iii) Low density polyethylene sheet or rubber sheet coating method

……3)

k≒ × 10^{-12}cm/sec

Popular as the leakage control work for irrigation-use reservoirs and the waste repository.

Large size production such as 5 m to 8 m in width and 50 m to 200 m in length.

Construction cost; 45 USD/m^2

7-6. Anti-infiltration work to reservoir bottom (2/2)

iv) Bentonite sheet coating method.....4)

$k \fallingdotseq 5 \times 10^{-9}$cm/sec

Popular as the leakage control work for irrigation-use reservoirs

No large/long size production.

Construction cost; 44 USD/m^2

v) Soil-cement coating method .....1)

$k \fallingdotseq 5 \times 10^{-8}$cm/sec

Popular as the low quality construction materials for civil works.

Rare as the anti-filtration works.

Big advantages in economy (14 USD/m^2), construction reliability/performance

however, it shall be confirmed if some hazardous chemical such as hexavalent chromium liquate will come out as well.

vi) Imperviousness-strengthened earth blanket coverage method. .2)

Mixing bentonite powder with soil or a bentonite film sandwiched by soil layers.

Construction cost; 18 USD/m^2

7-7. Construction area of anti-infiltration countermeasure

Permeability test results to the reservoir basement

No.	Formations	Permeability Coefficient (cm/s)
1	Recent Loamy sand, loam ($vdpQ_{IV}$)	1.97×10^{-4}
2	Sand and gravel/pebble (paQ_{IV})	5.03×10^{-3}
3	Recent Eluvial, Deluvial formation ($_{ed}Q_{IV}$)	1.63×10^{-3}
4	Late Quaternary Tuffs (βQ_{III})	4.68×10^{-3}
5	Middle Qua. Andecite lava (βQ_{II})	8.04×10^{-3}
6	Early Qua. Lap-ap-lap Q_{IV}	1.16×10^{-5}
7	Early Qua. Alluvial/proluvial sediments	3.08×10^{-3}
8	Late Pliocene, volcanic rocks	3.24×10^{-4}
9	Middle Pliocene,Pumices ($_{\beta}Q_{I}$)	1.57×10^{-2}
10	Andecite/Scoria ($_{\beta}N_2$)	9.83×10^{-3}
11	Andecite layer (N_1)	2.83×10^{-3}
	Ave,.	4.67×10^{-3}

1) Quantity of water seeping out through the borehole wall ⇒k_h

2) Anisotropy in permeability between k_h and k_v in horizontally deposited layers

3) $k=1.97 \times 10^{-4}$cm/sec ; horizontal permeability coefficient

4) Remarkable anisotropy in sandy clay layers ⇒ low k_v ⇒ no need countermeasure
⇒ small area of countermeasure

8. Project costs and financial analysis (1/7)

8-1. Project costs <Conditions>

1) Base; Updated cost as of March 2013 based on estimation during Soviet time,
2) Added;
   a) Rehabilitation of Kasakh river intake (50% of canal construction cost),
   b) Improvement of secondary / tertiary canals (50% of canal construction cost),
   c) Consultant fee including geotechnical, topo-surveys (10% of construction cost)
   d) Contingencies (Physical and Financial: 15%+4%)

3) Comparison of anti-infiltration methods for reservoir basin

Unit construction cost in Japan		
iii) Rubber, iv) Bentonite sheets	v) Soil cement	vi) Imperviousness strengthened earth blanket
45 USD/m^2	14 USD/m^2	18 USD/m^2

Conditions		
Coating area	Cost for dike construction	Conversion rate in RA
600ha	200%	80%

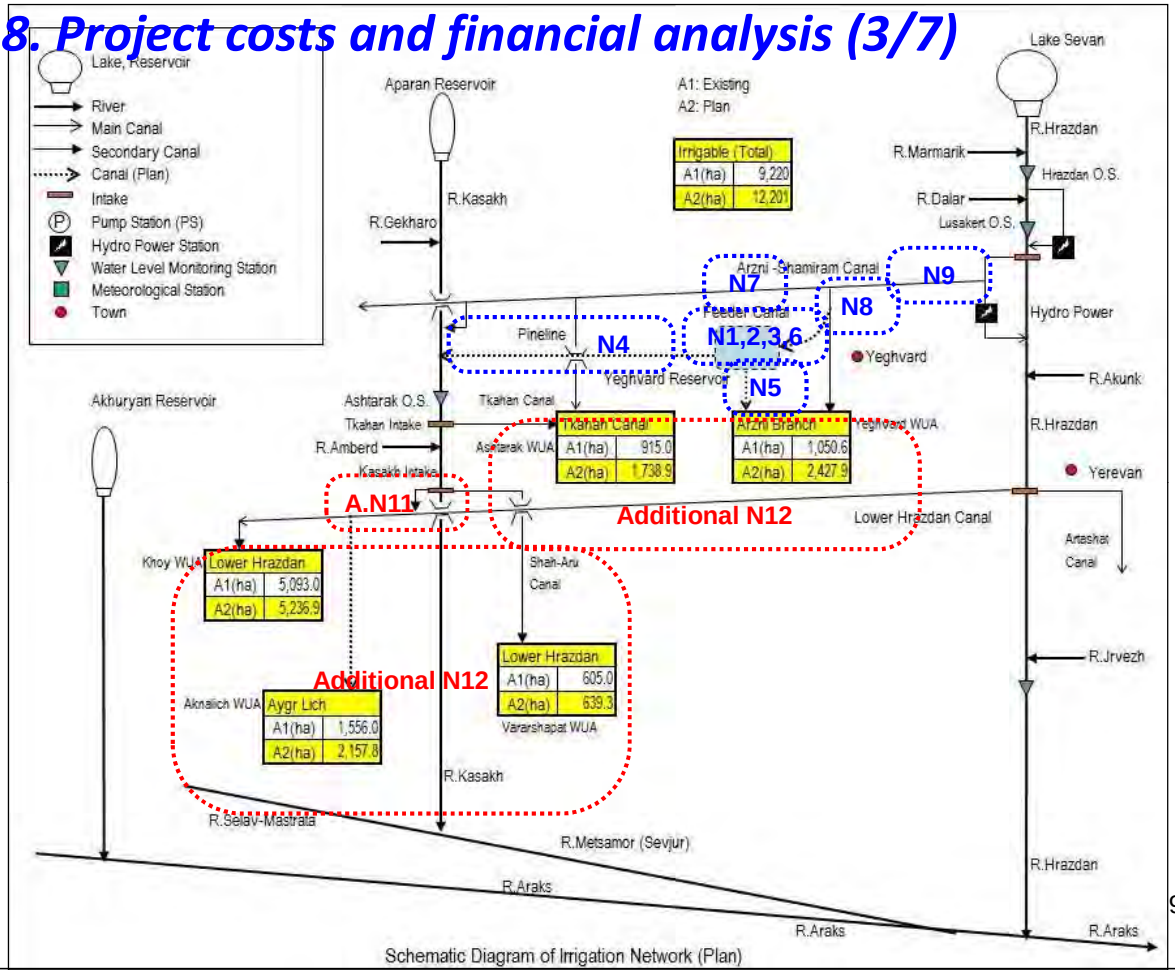
8. Project costs and financial analysis (2/7)

			iii) Rubber sheet iv) Bentonite sheet	v) Soil cement	vi) Imperviousness strengthened earth blanket
		Construction cost in Japan (USD/m2)	45	14	18
		Conditions	Cost for dikes	Coating area	Armenian rate
			200%	6,000,000m2	80%

As of March 2013 — 1 USD=415AMD

No.	Component	Main works	Estimated construction cost: 0)Bentonite sheet based on Armenia request A=10,000,000 m2		iii) Rubber sheet iv) Bentonite sheet	v) Soil cement	vi) Imperviousness strengthened earth blanket
			'000 AMD	'000 USD	'000 USD	'000 USD	'000 USD
N1	Reservoir basin	Polyethlene sheet instllation; 10 million m2 (Appr. 3km x 3km) Clay-sand, alumina transferring, loading and laying; 7.5 million tons Gravel transferring, loading and laying; 5.4 million tons	32,201,555	77,594	216,000	67,200	86,400
N2	Dam No.1	Clay-sand, alumina demolition and transferring; 1.5 million tons Creating clay screen; 861 m3 Gravel transferring, loading and laying; 0.8 million tons	4,354,336	10,492	20,985	20,985	20,985
N3	Dam No.2	Clay-sand, alumina demolition and transferring; 1.2 million tons Creating clay screen; 672 m3 Gravel transferring, loading and laying; 0.8 million tons	3,887,198	9,367	18,733	18,733	18,733
N4	Irrigation outlet from Dam No.1 -->Kasakh River	Concrete work; 5,600 m3 Re-bar instllation; 336 tons Metal pipe (D=1.6m) instllation; 160m	575,971	1,388	1,388	1,388	1,388
N5	Irrigation outlet from Dam No.2 -->Arzni Branch area, Feeding pipeline 1, Simultaneously outlet 2 (DM 129+5)	Concrete work; 2,000 m3 Re-bar instllation; 120 tons Metal pipe (D=1.4m) instllation; 148m	309,570	746	746	746	746
N6	Embankment (Serving as the reservoir shore protection structure)	Removing and transferring humus (surface soil); 74,400 tons Grassing and watering; 76,000 m2	162,198	391	782	782	782
N7	Feeding canal (1) Arzni-Shamiram to the Reservoir	Removing and transferring humus (surface soil); 1.4 m3 Backfilling clay-sand by hand; 400 m3 GRP pipe D=0.6 m; 1,100 m3	46,875	113	113	113	113
N8	Feeding canal (2) Arzni-Shamiram to the Reservoir	Removing and transferring humus (surface soil); 74 m3 Backfilling clay-sand by hand; 20,000 m3 GRP pipe D=2.6 m; 3,700 m3	1,882,440	4,536	4,536	4,536	4,536
N9	Rehabilitation of Arzni-Shamiram canal	Detonation; 10,000 m3, Filling gravel, sand; 10,000 m3 Concrete work (including demolition canal, insallation); 15,000 m3 Re-bar installation; 450 tons	1,122,133	2,704	2,704	2,704	2,704
N10	**Sub-total**		**44,542,276**	**107,331**	**265,987**	**117,187**	**136,387**
	Value added Tax	(20%)	8,908,455	21,466	53,197	23,437	27,277
	Total		**53,450,731**	**128,797**	**319,184**	**140,624**	**163,664**
Added Items							
	Sub-total of N4,N5,N6,N7,N8,N9 (Canal developm	4,099,187					
N11	**Improvement of Kasakh Intake;**	**Tentative 50% of canal development??**	**2,049,593**	**4,939**	**4,939**	**4,939**	**4,939**
N12	**Improvement of Secondary /Tertiary canals**	**Tentative 50% of canal development??**	**2,049,593**	**4,939**	**4,939**	**4,939**	**4,939**
N13	**Sub-total (N10+N11+N12)**		**48,641,462**	**117,208**	**275,864**	**127,064**	**146,264**
N14	Price escalation (in 2013)	5%	2,432,073	5,860	13,793	6,353	7,313
N15	**Sub-total (N13+N14)**		**51,073,535**	**123,069**	**289,657**	**133,417**	**153,577**
N16	Consultant fee (Enginering & Construction supervision)	10%	5,107,354	12,307	28,966	13,342	15,358
N17	**Sub-total (N15+N16)**		**56,180,889**	**135,376**	**318,623**	**146,759**	**168,935**
N18	Physical contingencies (Kaps)	15%	8,427,133	20,306	47,793	22,014	25,340
N19	Finacial contingencies (Kaps)	4%	2,247,236	5,415	12,745	5,870	6,757
N20	**Total (N17+N18+N19)**		**66,855,258**	**161,097**	**379,162**	**174,643**	**201,033**
N21	Value added Tax	(20%)	13,371,052	32,219	75,832	34,929	40,207
	Grand Total		**80,226,310**	**193,316**	**454,994**	**209,572**	**241,239**

8. Project costs and financial analysis (3/7)



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8. Project costs and financial analysis (4/7)

8-2. Project benefits <Conditions>

1) Construction period: 5 years
2) Life of constructed facility: 30 years
3) Project benefits
   a) Farmer's increment of income by increased crop production,
   b) Benefits from livestock production by the increased fodder crops,
   c) Cost-saving of pumping cost during the post-project period.

Coating method	Project Cost (Million USD)	Benefit ('000 USD)				FIRR	B/C
		a) Crop	b) Live-stock	c) O/M reduction	Total		
0) Bentonite based on Armenian request	193	8,362	1,613	1,750	11,725	4.2%	0.45
iii) Low density rubber sheet, or iv) Bentonite sheet	455					-1.3%	0.20
v) Soil cement	210					3.6%	0.43
vi) Imperviousness strengthened earth blanket	241					2.6%	0.37

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8. Project costs and financial analysis (5/7)

8-3. Project plans by other donors

Project (Option)	Dam / Reservoir			Irrigation			Project cost Million USD (Unit cost :USD/ha)	FIRR EIRR
	Dam height (m)	Dam vol. (MCM)	Reservoir surface area ($000m^2$)	Water require. (MCM/y) (Saving irrigation %)	Existing pumped area (%) →after project	Planned irrigation area (ha) (W. Require.) (m^3/ha)		
Kaps Stage-1 (Option-2)	55m	25 MCM	Approx 2,500	Approx. 12MCM (Saving Irrigation: S.I. 100%)	n.f.% → 0%	2,280ha (5,300m^3/ha)	94 M.USD (41,200/ha)	9.4% 15.0%
Kaps Stage-2	74m	60 MCM	Approx. 3,500	Approx. 44MCM (S.I. 100%)		8,070ha (5,400m^3/ha)	Not found	5.6% 11.5%
Vedi Option-1	Not found	29 MCM	Not found	32MCM (S.I. 50%)	77% → decrease	2,440ha (13,100/ha)	162 M.USD (66,400/ha)	EIRR 1.4%
Vedi Option-2	78m	40 MCM	Approx. 1,250	38MCM (S.I. 50%)		2,820ha (13,500/ha)	197 M.USD (69,900/ha)	EIRR 1.35%
Yeghvard reference	30-35m	90-110 MCM	Approx. 10,000	145MCM (S.I. 0%)	12% → 0%	12,200ha (12,100/ha)	190 M.USD (at request+) (15,600/ha)	Not yet

8. Project costs and financial analysis (6/7)

8-4. Validity of constructing Yeghvard reservoir

1. The IRR of the Vedi project is low, and that of Kaps is conceived to have a similarly low level because it includes the benefit of the risk of dam collapse,
2. The Yeghvard reservoir has a quite larger water surface area (reservoir bottom) than other two projects (Kaps and Vedi),
3. Thus escalation of the project cost is anticipated depending on the type of work adopted for sustainable measures for anti-infiltration.
4. On the other hand, about 50MCM/year of water currently relying on the Lake Sevan (equivalent to about 30% of the limit of discharge from the Lake, 170MCM/year) can be saved by constructing the Yeghvard Reservoir.
5. Depending on how to calculate the benefit of this project, a high possibility is expected to make the project feasible / acceptable.

8. Project costs and financial analysis (7/7)

8-5. Expectation of project cost reduction

Anisotropy in permeability (horizontal and vertical)

- Permeability coefficient: $k=1.97 \times 10^{-4}$ in the results of hydro-geological survey at Soviet time might be adopted as vertical permeability,
- If the area of reservoir basin requiring coating becomes smaller, project cost will be reduced.

8-6. Expectation of project viability

Saving water utilization of the Lake Sevan;

- Though FIRR is low, the Project will contribute not to consume approx. 50MCM/year or 30% of 170MCM, i.e. annual limit discharge of the Lake.
- This would effect; a)raising water level, b)saved water can be used for other purpose, c)promoting fish culture, d)conserving environment, e)tourism development, etc.

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9. Some conditions to make a decision for the implementation of Yeghvard Irrigation Project

Armenian national policies in water sector say;

1) "Water resources conservation (it means the conservation of Lake Sevan)" is the top-most priority for the nation,
2) Water usage for agricultural purpose is placed next priority except uses of tradition and international law, and
3) Shifting irrigation system from pump to gravity is fundamental strategy.

Status surrounding the Yeghvard Irrigation Project, If the project were required to make it scale down;

1) To allow consuming water of Lake Sevan for the Project,
2) To retain an existing pump station (Rancchabar) in the Project area, and/or
3) To make smaller a capacity of the planned reservoir → to limit the beneficial area of the Project.

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Thank you very much!

Mt. Fuji (in Japan), Source: Wikipedia

Appendixes

Appendix-A Results of Farm-households Questionnaire Survey

1. Survey Target Areas

The survey was carried out in 5 WUAs in 4 Marzes recommended by PIU during 8th -11th July, 2014. In total, 20 farm-households (WUA members) were selected for the survey. The table below shows name of the selected WUAs, including landscape of their area, and number of sample farm-households from each WUA.

Table A-1 Outline of WUAs Surveyed

Marz	WUA & Number of Sample Farmers	Agro-economic Zone	Land Scape & Altitude	Distant from Yelevan
Aragatsotn	Ashtarak (3)	Hilly area	Moderate slope with semi-higher altitude (1,100 m)	25 km
	Shamiram (2)	Hilly area	-Ditto- (1,200 m)	50 km
Shirak	Shirak (5)	Mountainous area	Plain with higher altitude (1,500m)	120 km
Armavir	Khoy (5)	Ararat plain area	Plain with lower altitude (900m)	25 km
Tavush	Noyemberyan (5)	Sub-tropical area	Moderate slope with lower altitude (500m)	220 km

2. Outline of the Surveyed Farm-households

(1) The average age of interviewee (the head of a family) is 53.8 in the range of 35-68. All interviewee are male, and they consist of mainly 50s (11 men) and 60s (5 men).

(2) 16 farm-households out of 20 have got their land-lights during 1991-93, while three farm-households have got the rights after the year 2000.

(3) The average farming career of interviewee is 24.5 years. It implies that many of them have started farming upon getting their land-rights after the independence in 1991. There are 6 interviewees who have more than 24 years farming career (started farming before the independence).

Table A-2 Average Age of the Farmers and their Experience in Farming

Marz	Age		Farming Experience (Year)		Farmers Experienced over 24 years
	Ave	Range	Ave.	Range	
Aragatsotn	55.2	44 – 64	27.6	22 - 40	2
Shirak	53.8	52 – 57	23.0	20 - 30	1
Armavir	58.2	41 – 68	31.4	21 - 50	2
Tavush	48.0	35 – 62	16.0	5 - 23	0
Total	**53.8**	**35 – 68**	**24.5**	**5 – 50**	**6**

(4) With respect to educational background of the interviewees, 11 interviewees are the graduate of middle school, 7 interviewees are the graduate of high school and 2 interviewees are the graduate of university of more.

(5) The average size of interviewees' family is 5.5/household. A typical family consists of parents, 3 children (1 is less than 14 years old) and 1 elder people (over 65 years old)

Table A-3 Family Members of the Farmers

Age	Male	Female	Total
Under 14	0.7	0.5	1.2
15 - 64	2.1	1.9	4.0
Over 65	0.2	0.2	0.3
Total	**3.0**	**2.5**	**5.5**

(Note) Total of "over 65" is not corresponds due to rounded calculation

(6) Out of family members of all interviewees, 26 members have a job in non-agriculture sector (male: 17 and female: 9). Most families have more than 1 family members who work in non-agricultural sector in average (only 4 interviewees have no family member who works in non-agricultural sector). The interviewees in Amarvir Marz have relatively small number of family members who work in non-agricultural sector.

Table A-4 Number of Employee in Non-Agri. Sectors per Family

Marz	Non-agriculture Permanent Employee		
	Male	Female	Total
Aragatsotn	5	2	7
Shirak	3	4	7
Armavir	3	1	4
Tavush	6	2	8
Total	**17**	**9**	**26**

3. Annual Income in 2013

(1) The average annual household income of interviewee in 2013 is 3,870 thousand AMD (Armenian Dram), while the maximum is 15,000 thousand AMD and the minimum is 600 thousand AMD. The average income is the highest in Armavir Marz, while the lowest is in Tavush Marz.

Table A-5 Average Annual Income of the Farmer Families in 2013

Marz	Annual Income in 2013 (Thousand AMD/household)	
	Ave	Range
Aragatsotn	4,760	800 – 15,000
Shirak	3,120	600 – 6,000
Armavir	5,500	1,500 – 13,000
Tavush	2,100	1,000 – 3,000
Total	**3,870**	**600 – 15,000**

(2) 18 farm-households out of 20 sample farm-households answer that their principle income source is crop farming. It seems that many farm-households manage their farming many depending on crop growing.

(3) 11 farm-households out of 20 sample farm-households answer that they have a certain income from livestock farming. Then, only one farm-household depends on livestock for their principle income. While the number of farm-households having income from livestock farming in Amarvir Marz is zero, livestock farming is an important subsidiary income source of farm-households in other Marzes.

(4) 16 farm-households out of 20 sample farm-households answer that they have an income (a salary or wages) from non-agricultural sector. Out of the 16 farm-households, 3 farm-households depend on their principle income from the salary or wages. Income from non-agricultural sector is also an important subsidiary income source of farm-households in all Marzes.

(5) None of sample farm-households have income from sales of handcrafts, while only 2 sample farm-households have income from self-employed business.

(6) Pension, remittance and public supports are not important for many sample farm-households.

Table A-6 Importance of Income Sources to the Farmer Families in 2013
(the smaller number is the more important item)

Income Source	Marz				Total
	Aragatsotn	Shirak	Armavir	Tavush	
Sales of crops	1	1	1	1	**1**
Sales of livestock/milk/eggs	4	2	-	3	**4**
Salary or wage (Agriculture)	3	2	3	4	**3**
Salary or wage (Non-agriculture)	2	2	2	2	**2**
Own business (self-employed)	5	-	5	-	**7**
Sales of handcraft	-	-	-	-	**-**
Pension of family members	6	6	3	5	**5**
Remittance	6	5	-	5	**6**
Public support	6	-	-	-	**8**
Others	-	-	-	-	**-**

4. Annual Expenditure in 2013

(1) The average annual household expenditure of interviewee in 2013 is 3,310 thousand AMD, while the maximum is 10,000 thousand AMD and the minimum is 600 thousand AMD. The average is highest in Armavir Marz and the lowest in Tavush Marz.

Table A-7 Average Annual Expenditure of the Farmer Families in 2013

Marz	Annual Expenditure in 2013 (Thousand AMD/household)	
	Ave	Range
Aragatsotn	2,660	800 – 5,500
Shirak	3,120	600 – 6,000
Armavir	5,560	2,800 – 10,000
Tavush	1,900	1,000 – 3,000
Total	**3,310**	**600 – 10,000**

(2) The highest expenditure item is “agricultural inputs and management” for all sample farm-households.

(3) The higher expenditure items are “foods & beverages” and “housing, home-consumables and public services”.

(4) Sample farm-households in Aragatsotn Marz and Armavir Mars spend relatively much for “clothes” and “electric appliances, furniture and durable goods”, while they don’t spend much for “social relations”. However, the farm-households in Shirak Marz and Tavush Marz have an opposite expenditure tendency

(5) All sample farm-households don’t spend much for “medical care & health” and “education and recreation”.

Table A-8 Importance of Income Sources to the Farmer Families in 2013
(the smaller number is the more spending item)

Expenditure Item	Marz				Total
	Aragatsotn	Shirak	Armavir	Tavush	
Agricultural inputs and management	1	1	1	1	**1**
Foods & beverages	2	2	2	2	**2**
Clothes	4	5	4	7	**5**
Housing, home-consumables and public services	3	2	2	4	**3**
Electric appliances, furniture and durable goods	4	7	4	7	**6**
Medical care & health	4	7	7	5	**6**
Education & recreation	7	6	8	6	**8**
Social relation	7	4	6	3	**4**
Others	9	9	9	9	**9**

5. Strategy to increase the Family's Living Standards in Future

(1) Many interviewees still keep a strong will to continue farming, since many of them answer that they devote themselves to farming to increase their living standards.

(2) On the other hand, almost a half of the interviewees answer that it is important to find out a new job/business and 75% of the interviewees answer that it is important to educate children for getting new job in order to increase their living standards in future. Those answers imply that a substantial number of farmers aren't confident in continuation of farming in the next generation.

(3) Though Armenia is famous in transmigration or migrant workers to foreign countries, the interviewees want to get a job in their hometown.

(4) About a half of the interviewees answer that they are interested in not only farming, but also in processing of farm products. However, none of interviewees in Armavir Marz are interested in.

Table A-9 Farmers' Strategy to Improve their Livelihood

Strategy	Number of Answered Farmers		
	Very important	Important	Less important
To devote to farming	16	3	1
To find out a new good job/business in the local area (including family members)	5	4	11
To go to other area/country for getting jobs (including family members)	0	1	19
To educate children for getting good jobs	7	8	5
To increase crop production from the own-land	18	2	0
To increase the number of livestock	4	5	11
To sell processed foods/products	6	3	11
Others	-	-	-

6. Farmland under Management

(1) The average farmland size managed by the interviewees' family is 3.67 ha. Out of the 3.67 ha, 2.75 ha is owned by the family while 0.93 ha is rented land.

(2) The average number of land title holders in the interviewees' family is 3.7 people. The title is divided by husband and wife, and adult children in general. Though farmland is fragmented into many land title holders, the land size managed by a farm-household may be kept to a certain size due to the multi land title holders in a family.

(3) It is observed that borrowing and lending of farmland is common in Armenia. However, there is no interviewees to lend out own farmland. Almost farmland lent out is annual crops growing land.

(4) Most parts of farmland are irrigated, while there are some rain-fed farmlands. The rain-fed farmland is used for annual crops growing and pasture in general.

(5) Annual crops land, the largest and orchard/vineyard occupy the farmland.

(6) Only one interviewee has own pasture, while there are 6 interviewees to grow cattle, sheep or goats

(7) Every interviewee has a small seize of home garden under irrigation.

Table A-10 Average Farmland Size of All Farmers in ha

Farm Land Use	Irrigation	Own-land			Lent from	Total
		Managed	Lent-out	S-total		
Annual crops (including forage crops)	Irrigated	1.29	0.00	1.29	0.70	1.99
	Rain-fed	0.23	0.00	0.23	0.15	0.38
	Total	1.52	0.00	1.52	0.85	2.37
Orchard/ vineyard	Irrigated	1.02	0.00	1.02	0.00	1.02
	Rain-fed	0.00	0.00	0.00	0.08	0.08
	Total	1.02	0.00	1.02	0.08	1.10
Pasture	Irrigated	0.00	0.00	0.00	0.00	0.00
	Rain-fed	0.04	0.00	0.04	0.00	0.00
	Total	0.04	0.00	0.04	0.00	0.04
Others (home garden, etc.)	Irrigated	0.17	0.00	0.17	0.00	0.17
	Rain-fed	0.00	0.00	0.00	0.00	0.00
	Total	0.17	0.00	0.17	0.00	0.17
Total	Irrigated	2.48	0.00	2.48	0.70	3.18
	Rain-fed	0.27	0.00	0.27	0.23	0.49
	Total	**2.75**	**0.00**	**2.75**	**0.93**	**3.67**

Note: Some totals are not corresponding to the breakdowns due to rounding error

(8) Farmland use of the interviewees by respective Marzes is shown as follows;

Table A-11 Indicative Farmland Use by Marzes in ha

Marz	Own-land	Lent-from	Farmland total	Crops	Orchard & Grape	Rain-fed
Aragatsotn	3.20	0.10	3.30	0.94	2.31	0.00
Shirak	2.34	1.30	3.64	3.33	0.00	1.06
Armavir	2.48	2.00	4.48	4.00	0.22	0.00
Tavush	2.96	0.30	3.26	1.20	1.86	0.06

7. Agricultural Production (Crops & Livestock) in 2013

(1) The most common crop for the interviewees is wheat, and the planted area is also the largest. Wheat is grown under rain-fed condition in Shirak Marz and Tavush Marz.

(2) The second common crop is potato which is a major food for farmers after wheat.

(3) There are a few interviewees to grow barley. Barley is grown for forage purpose.

(4) Among forage crops, only alfalfa is grown by the interviewees. Alfalfa is combined with wheat and potato.

(5) Limited number of the interviewees grows vegetables except for the plantation in home garden. The planted area is also very small. Tomato, cabbage and cucumber are popular vegetables among the interviewees.

(6) As same as vegetables, limited number of the interviewees grows fruits (including grape) except for the plantation in home garden. However, the planted area is larger than the area of vegetables. Apple, peach and grape are popular fruits among the interviewees.

(7) There are several interviewees to breed livestock except for chicken. There is only one interviewee to breed sheep and goats.

(8) Most interviewees grow necessary forage crops for own livestock by themselves. Major fodder sources for the livestock are public grazing land for cattle, grazing land (own and public) for sheep/goats, commercial feed for pigs, and commercial feed and backyard for chicken.

Table A-12 Crop Production of Sample Farmers in 2013

Crop	Farmers to grow*	Total Area (ha)	Average Area (ha/ farmer)	Total Production (ton)	Yield (ton/ha)
Wheat	15	25.30	1.69	90,200	3.57
Barley	2	1.50	0.75	6,300	4.20
Forage (Alfalfa)	5	5.70	1.14	21,000	3.68
Potato	7	11.92	1.70	392,000	32.89
Sunflower	3	3.10	1.03	6,500	2.10
Tomato	5	0.23	0.05	18,100	80.44
Cabbage	3	0.52	0.17	24,200	46.72
Cucumber	5	1.16	0.23	29,800	25.69
Eggplant	1	0.60	0.60	12,000	20.00
Water melon	1	0.01	0.01	700	70.00
Strawberry	2	0.60	0.30	5,000	8.33
Grape	5	5.64	1.13	43,000	7.63
Apple	7	7.40	1.06	177,100	23.9
Apricot	1	0.50	0.50	500	1.00
Peach	5	NA	NA	NA	NA
Persimmon (new crop)	3	NA	NA	NA	NA
Pear	1	NA	NA	NA	NA

(Note) * >0.01ha for vegetables, and >0.1ha for other crops

Table A-13 Number of Livestock Raised by Sample Farmers in 2013

Livestock	Farmers to raise	Adult	Young Animals	Total Livestock	Livestock per Farmer
Cattle & Cow	6	30	26	56	9.3
Sheep & Goat	1	10	8	18	18.0
Pig	4	15	45	60	15.0
Poultry (Chicken)	12	285	160	445	37.1

Table A-14 Management of Fodders in 2013

Livestock	Importance	Number of Answered Farmers				
		Self-Production	Buy from Outside	Grazing (own-land)	Grazing (public)	Total
Cattle & Cow	Principle	5	0	0	3	6
	Major Substitute	0	1	1	2	
	Minor Substitute	1	1	1	0	
	No/Negligible	0	4	4	1	
Sheep & Goat	Principle	1	0	0	0	1
	Major Substitute	0	0	1	1	
	Minor Substitute	0	1	0	0	
	No/Negligible	0	0	0	0	
Pig	Principle	3	1	0	0	4
	Major Substitute	0	0	0	0	
	Minor Substitute	1	1	0	0	
	No/Negligible	0	2	4	4	
Poultry	Principle	9	0	0	0	11
	Major Substitute	0	1	1	0	
	Minor Substitute	1	3	5	1	
	No/Negligible	1	7	5	10	

(9) Farming of the interviewees in respective Marzes is summarized as follows;

<Aragatsotn Marz>

Fruits (including grape) farming is the most important farming, and livestock and crop farming are subsidiarily combined. Among fruits, grapes are much grown in low altitude areas while apples are grown in high altitude areas in general. Cattle and chicken are major livestock. Few vegetables are grown except for the self-consumption in home garden.

<Shirak Marz>

Wheat, potato and livestock (mainly cattle) are well combined in a farming system. Few vegetables and fruits are grown except for the self-consumption in home garden.

<Armavir Marz>

Wheat, potato and vegetables are combined, while fruits farming are also popular to some extent. Vegetables are the most important cash income source for many farmers, and they are grown not only in open field but also in tunnel or green house with drip irrigation system. Livestock farming is not popular.

<Tavush Marz>

Fruits farming are the most important farming, and livestock and crop farming are subsidiarily combined. While peaches are major fruits in the area, persimmons are becoming popular in recent years. Sunflower is more popular than the other Marzes. Pigs and chicken are major livestock. Few vegetables are grown except for the self-consumption in home garden.

Table A-15 Crop/Livestock Growing Farmers by Marz in 2013

Crop/Livestock	Number of Farmers*				
	Aragatsotn	Shirak	Armavir	Tavush	Total
Wheat	2	5	5	3	**15**
Barley	0	1	1	0	**2**
Forage (Alfalfa)	2	3	0	0	**5**
Potato	0	3	4	0	**7**
Sunflower	0	0	0	3	**3**
Tomato	0	0	4	1	**5**
Cabbage	0	1	2	0	**3**
Cucumber	0	1	4	0	**5**
Eggplant	0	0	1	0	**1**
Water melon	0	0	0	1	**1**
Strawberry	0	0	2	0	**2**
Grape	3	0	1	1	**5**
Apple	4	0	1	2	**7**
Apricot	1	0	0	0	**1**
Peach	0	0	1	4	**5**
Persimmon (new crop)	0	0	0	3	**3**
Pear	0	0	0	1	**1**
Cattle & Cow	2	4	0	0	**6**
Sheep & Goat	0	1	0	0	**1**
Pig	1	1	0	2	**4**
Poultry (Chicken)	3	4	2	3	**12**

(Note) *>0.01ha for vegetables, and >0.1ha for other crops

(10) A clop calendar of major crops is made based on collected information from the interviewees (See Figure A-1).

(11) The main labor force for farming is husband, and wife and adult sons play a supporting role. Adult daughters also support farming to some extent, not as much as adult sons.

(12) The role of old person and small children is quite limited regardless of sex.

(13) Women share almost equal responsibility with men for managing small animal, i.e. pigs and chicken.

(14) Farm labors are hired and play a certain important role in growing cereals, vegetables and fruits. However, no labor is hired for breeding livestock by the interviewees.

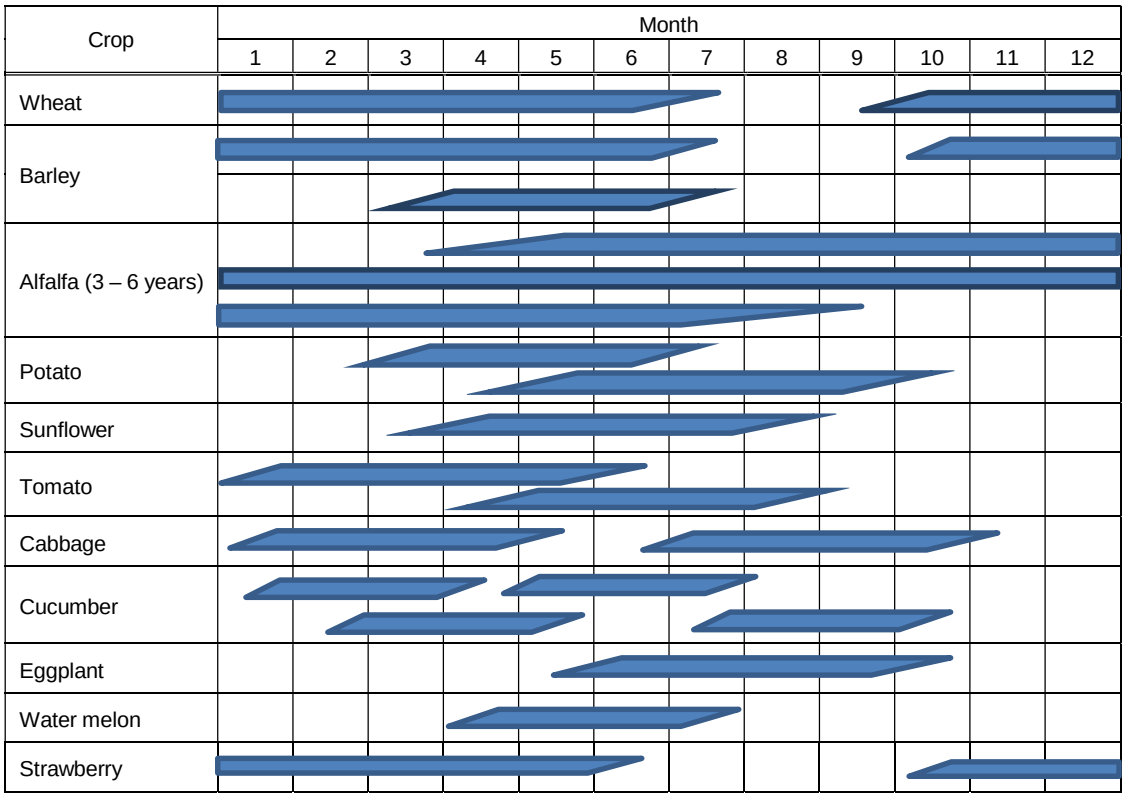


Figure A-1 Crop Calendar of Major Crops

Table A-16 Labor Forces for Farming

Crop/Livestock (No. of answers)	Work input	Hus-band	Wife	Other adult		Old people		Children		Hired labor
				Male	Fe-male	Male	Fe-male	Male	Fe-male	
Wheat & grains (14)	Main	11	2	3	1	0	0	0	0	3
	Assist	2	9	7	4	0	1	3	3	2
	No	1	3	5	9	14	13	11	13	9
Fodder crops (5)	Main	5	1	1	0	0	0	0	0	0
	Assist	0	3	3	1	0	1	1	0	0
	No	0	1	1	4	5	4	4	0	0
Vegetables, melons & potato (13)	Main	10	3	4	1	0	0	0	0	4
	Assist	2	8	4	4	0	0	1	1	1
	No	1	2	5	8	13	13	12	12	8
Fruits & grape (13)	Main	11	2	1	0	0	0	0	0	4
	Assist	1	9	5	5	0	1	2	2	2
	No	1	2	7	8	13	12	11	11	7
Cattle & cow (6)	Main	5	2	1	0	1	0	0	0	0
	Assist	1	4	4	1	0	1	1	1	0
	No	0	0	1	5	5	5	5	5	6
Sheep & goat (1)	Main	1	0	0	0	0	0	0	0	0
	Assist	0	1	1	0	0	0	0	0	0
	No	0	0	0	0	0	0	0	0	0
Pig (4)	Main	2	2	0	0	0	0	0	0	0
	Assist	2	2	2	1	0	0	1	1	0
	No	0	0	2	3	4	4	0	0	4
Poultry (12)	Main	5	6	0	1	1	1	0	0	0
	Assist	6	5	5	2	0	1	2	4	0
	No	1	1	7	9	11	10	10	8	12

8. Marketing of Farm Products in 2013

(1) While a part of farm products is allocated for own consumption, a certain ratio of the products is marketed. Subsistence farming is not popular among the interviews. However, wheat which

is the most important staple food in Armenia is grown preferentially for fulfilling own needs by farmers in general cases.

(2) Many interviewees produce chicken meat, eggs, alfalfa and wheat exclusively for own consumption. Several farmers cannot harvest fruits as they are still too young to get fruits.

Table A-17 Number of Farmers to Produce and Sale the Products in 2013

Products	Number of Farmers	
	Production	Sale
Wheat	15	11
Barley	2	2
Alfalfa	5	1
Potato	7	7
Sunflower	3	3
Tomato	5	5
Cabbage	3	3
Cucumber	5	4
Eggplant	1	1
Water melon	1	0
Strawberry	2	2
Grape	5	3
Apple	7	5
Apricot	1	0
Peach	5	3
Persimmon (new crop)	3	1
Pear (young trees)	1	0
Beef meat	5	5
Milk	4	3
Ram meat	1	1
Pork meat	4	4
Chicken meat	12	0
Egg	12	3

Note: Products from home-garden are not included

(3) The interviewees sell their products mainly to middlemen. A small part of vegetables and fruits are also retailers directly. All grapes are sold to brewery companies, maybe under contract farming. The interviewees generally sell produced meats and eggs directly to consumers.

Table A-18 Buyers of the Products in 2013

Products	Major Buyer					
	Govt. or its agent	Company /Coop.	Middle-man	Exporter	Retailer	Consum-er
Wheat	0	2	7	0	1	1
Barley	0	0	2	0	0	0
Alfalfa	0	0	0	0	0	1
Potato	0	0	5	2	0	2
Sunflower	0	1	2	0	0	0
Tomato	0	0	2	0	1	1
Cabbage	0	0	2	0	1	0
Cucumber	0	0	2	0	1	0
Eggplant	0	0	1	0	0	0
Strawberry	0	0	2	0	0	0
Grape	0	3	0	0	0	0
Apple	0	0	3	0	1	2
Peach	0	0	1	0	2	0
Persimmon	0	0	1	0	0	0
Beef meat	0	0	1	0	2	2
Milk	0	1	1	0	0	0
Ram meat	0	0	0	0	0	1
Pork meat	0	0	1	0	0	3
Egg 3	0	0	0	0	1	2

(4) Most of the products are sold at farm-gate.

(5) Small number of interviewees brings a part of their products, vegetables, i.e. fruits and meats to the nearest market. Most of the brought products are sold directly to consumers, while the farmers to sell the products usually get price information from middlemen.

(6) According to self-declaration of the interviewees, averaged their selling prices of farm products (at farm-gate) are shown in Table A-21. The prices of vegetables and fruits fluctuate much, probably due to a seasonal factor and a quality factor.

Table A-19 Marketing Places of the Products in 2013

Products	Marketing Place			
	Farm-gate	Market /Bazar	Collecting point	Other
Wheat	10	0	0	1
Barley	1	0	1	0
Alfalfa	0	0	1	0
Potato	7	1	0	0
Sunflower	2	0	0	1
Tomato	3	1	0	0
Cabbage	3	1	0	0
Cucumber	3	0	0	0
Eggplant	1	0	0	0
Strawberry	2	0	0	0
Grape	0	0	0	3
Apple	3	2	1	0
Peach	2	1	0	0
Persimmon	1	0	0	0
Beef meat	3	2	0	0
Milk	2	0	0	0
Ram meat	1	0	0	0
Pork meat	3	1	0	0
Egg	3	0	0	0

Table A-20 Buyers and Price Information Sources in Direct Market Sales in 2013

Cases of Direct Market Sales	Buyers		Price Information Source	
	Consumer	Others	Middleman	Others
9	6	3	6	3

Table A-21 Farmers' Selling price of the Products in 2013

Products	(AMD/kg)	
	Price	Range
Wheat	142.3	100 - 200
Barley	145.0	140 - 150
Alfalfa	40.0	-
Potato	99.4	60 - 150
Sunflower	576.7	500 – 700
Tomato	142.5	100 - 200
Cabbage	136.7	80 - 180
Cucumber	63.3	30 - 130
Eggplant	50.0	-
Strawberry	400	300 - 500
Grape	141.7	135 - 150
Apple	175.3	150 - 250
Peach	120.0	50 - 160
Persimmon	200.0	-
Beef meat	1,980.0	1,900 – 2,000
Milk	140.0	130 - 150
Ram meat	1,500.0	-
Pork meat	2,325.0	1,800 – 3,000
Egg	53.3	50 - 60

9. Irrigation

(1) The average irrigated farmland per interviewee is 2.98 ha. While many interviewees irrigate crops by basin or fallow irrigation method, interviewees in Armavir Marz have introduced a drip irrigation system.

(2) The irrigated farmland area in Armavir Marz is remarkably bigger than the other 3 Marzes

(3) There are 4 interviewees to install own irrigation tube-well and pump up water by electric motor in Armavir Marz.

Table A-22 Average Farmer's Irrigated Area by Types of Irrigation in ha in 2013

Irrigation	Marz				Total
	Aragatsotn	Shirak	Armavir	Tavush	
Basin or fallow	2.81	2.23	4.32	2.31	2.92
Sprinkler	0.00	0.00	0.00	0.00	0.00
Drip	0.00	0.00	0.25	0.00	0.06
Total	2.81	2.23	4.57	2.31	2.98

(4) A period possible to irrigate crops from the closest irrigation system differs from interviewee to interviewee. The period by Marzes are summarized in Table A-23. Amarbir Mrarz has a remarkable advantageous position in the irrigation period as well.

Table A-23 Irrigation Period of Canal Irrigation in 2013

Marz	Start (month)	End (month)
Aragatsotn	April	October
Shirak	June	Mid-September
Armavir	April	November
Tavush	Mid-April	September

(5) There are 16 interviewees who can control irrigation timing and amount of irrigation water by them themselves. It seems that farmers have a certain level of free hand in managing own irrigation at the field level. In Tavush Marz, there are only 2 interviewees out of the 5 interviewees who can control irrigation water by them themselves. The all 4 interviewees who cannot control the irrigation water say that WUA is responsible for the water control.

(6) There are 16 interviewees who receive irrigation water directly from an irrigation canal, while 4 interviewees (2 each in Aragatsotn Marz and Armavir Marz receive irrigation water only through the neighbor's field.

(7) Many interviewees are satisfied with the irrigation service in terms of quantity and in quality, but the number is less in Tavush Marz.

Table A-24 Quantity and Quality of Irrigation Water in 2013

Marz	Number of Farmers	
	Enough Quantity	Good Quality
Aragatsotn	4	5
Shirak	5	5
Armavir	4	4
Tavush	3	2
Total	16	16

(8) Amount of annual irrigation water charge per ha paid in 2013 varies among the interviewees, because a different amount is charged based on growing crops in accordance with the designated standard water requirement of the crops. The interviewee, who grows high water consuming crop such as vegetables, pays the higher charge.

Table A-25 Irrigation Water Charge in 2013

Marz	AMD/ha/year	
	Average	Range
Aragatsotn	48,250	20,000 – 73,000
Shirak	28,600	13,000 – 50,000
Armavir	60,600	43,000 – 81,000
Tavush	36,000	24,000 – 40,000
Total	43,105	13,000 – 81,000

10. Use of Farm Inputs

(1) Commercial Seeds/Seedlings

Commercial seeds/seedlings are widely used for potato, vegetables and other cereals (barley and sunflower), but rarely used for alfalfa and fruits.

Table A-26 Commercial Seeds/Seedling Use in 2013

Crop	No. of Answers	Use	No Use
Wheat	16	10	6
Other Cereals	4	3	1
Alfalfa	5	1	4
Potato	12	11	1
Vegetables & Melon	12	9	3
Fruits & Grape	13	3	10

(2) Organic Manure

Organic manure is used much for potato, vegetables and fruits. Cattle dung, which is major material of organic manure, is widely used for fuel source after drying in rural area, and farmers are not able to keep enough amount of cattle dung for making organic manure. Due to such situation, organic manure is used only for cash-income oriented crops.

Table A-27 Organic Manure Use in 2013

Crop	No. of Answers	Use	No Use
Wheat	16	5	11
Other Cereals	4	2	2
Alfalfa	5	0	5
Potato	12	7	5
Vegetables & Melon	12	9	3
Fruits & Grape	13	8	5

(3) Chemical Fertilizers

Chemical fertilizers are the most popular agricultural inputs, and they are widely used for all crops except for alfalfa.

Table A-28 Chemical Fertilizers Use in 2013

Crop	No. of Answers	Use	No Use
Wheat	16	13	3
Other Cereals	4	3	1
Alfalfa	5	2	3
Potato	12	11	1
Vegetables & Melon	12	8	4
Fruits & Grape	13	11	2

(4) Fungicides

While fungicides are the least popular chemicals among fungicides, insecticides and herbicide, they are widely used for potato, vegetables and fruits.

Table A-29 Fungicide Use in 2013

Crop	No. of Answers	Use	No Use
Wheat	16	8	8
Other Cereals	4	1	3
Alfalfa	5	1	4
Potato	12	11	1
Vegetables & Melon	12	9	3
Fruits & Grape	13	9	4

(5) Insecticides

Insecticides are widely used for all crops except for other cereals (barley and sunflower).

Table A-30 Insecticides Use in 2013

Crop	No. of Answers	Use	No Use
Wheat	16	11	5
Other Cereals	4	0	4
Alfalfa	5	4	1
Potato	12	12	0
Vegetables & Melon	12	11	1
Fruits & Grape	13	12	1

(6) Herbicides

Herbicides are also widely used for many crops, even not like insecticides.

Table A-31 Herbicide Use in 2013

Crop	No. of Answers	Use	No Use
Wheat	16	12	4
Other Cereals	4	3	1
Alfalfa	5	2	3
Potato	12	11	1
Vegetables & Melon	12	10	2
Fruits & Grape	13	9	4

(7) Farm Machinery

Farm machinery is commonly used for cereals, but not used much for other crops.

Table A-32 Farm Machinery Use in 2013

Crop	No. of Answers	Use	No Use
Wheat	16	10	6
Other Cereals	4	3	1
Alfalfa	5	2	3
Potato	12	5	7
Vegetables & Melon	12	2	10
Fruits & Grape	13	5	8

(8) Artificial Insemination

Artificial insemination is not popular among the interviewees.

Table A-33 Artificial Insemination Use in 2013

Crop	No. of Answers	Use	No Use
Cattle & Cow	6	2	4
Sheep & Goat	1	1	0
Pig	4	1	3
Poultry	11	1	10

(9) Commercial Feeds

Commercial feeds are also not popular. The interviewees usually feed animals on their own produced forage and collected grass hay, and graze animals during summer season.

Table A-34 Commercial Feeds Use in 2013

Crop	No. of Answers	Use	No Use
Cattle & Cow	6	2	4
Sheep & Goat	1	1	0
Pig	4	2	2
Poultry	11	5	6

(10) Vaccination

Vaccination is widely accepted by the interviewees, and almost livestock are vaccinated.

Table A-35 Vaccination Use in 2013

Crop	No. of Answers	Use	No Use
Cattle & Cow	6	6	0
Sheep & Goat	1	1	0
Pig	4	4	0
Poultry	11	9	2

(11) Animal Medicine

Animal medicine is also popular, and widely used except for poultry.

Table A-36 Medicine Use in 2013

Crop	No. of Answers	Use	No Use
Cattle & Cow	6	5	1
Sheep & Goat	1	1	0
Pig	4	3	1
Poultry	11	6	5

(12) Hormone Drug

Few the interviewees use hormone drugs for their animals.

Table A-37 Hormone Drug Use in 2013

Crop	No. of Answers	Use	No Use
Cattle & Cow	6	1	5
Sheep & Goat	1	1	0
Pig	4	1	3
Poultry	11	1	10

11.Procurement Source of Farm Inputs

(1) While some interviewees procure commercial seeds/seedlings from private traders, they should be vegetables seeds/seedlings and fruits seedlings. Some interviewees also procure seeds from the government, maybe through the government supporting programs.

(2) Some interviewees produce organic manure by them themselves, while some other interviewees buy the manure from market or neighbors.

(3) Interviewees buy chemical fertilizers mainly through the government channel, and subsidiary buy from commercial traders. Many farmers in Armenia depend on the government supporting program to procure chemical fertilizers. However, due to inflexible system of the government program, such as pre-order sale for 1 year demand, famers also buy chemical fertilizers from private traders when they suddenly need an additional application, even though the selling

price is higher than the government price.

(4) In case of agro-chemicals, i.e. fungicides, insecticides and herbicide, interviewees buy the chemicals mainly from private traders. There is no government support program for agro-chemicals like chemical fertilizers. There are only two cases of agro-chemicals supply from research institutes. This is maybe the case for a pilot experiment before a full-scale introduction.

(5) Interviewees buy commercial feeds mainly from private traders, while some interviewees buy from neighbors.

(6) Many interviewees get a vaccination service from the government sector. Even not confirmed yet, there should be a government support program for vaccination. By contraries, interviewees mostly depend on private traders for procurement of animal medicine and hormone drugs.

(7) Some interviewees have own farm machinery, while some other interviewees depend on farm machinery services from the private sector.

Table A-38 Procurement Source of Inputs in 2013

Inputs	Number of Answered Farmers				
	Self management	Govt. or State company	Research institute	Private or Market	Neighbors
Commercial seeds/seedlings	NA	6	0	8	1
Organic manure	8	0	0	5	3
Chemical fertilizers	NA	12	0	9	0
Agro-chemicals (pesticide, etc.)	NA	0	2	17	0
Artificial insemination	NA	0	0	2	0
Commercial feeds	NA	0	0	2	1
Vaccination service	NA	10	0	2	0
Medicine/hormone	NA	2	0	7	0
Machinery service	9	0	0	7	0

12.Possession of Farm Machinery and Facilities

(1) Tractor is the most popular farm machinery. More than a half of interviewees have a tractor, and four of them have more than 2 tractors.

(2) As for tractor implements, seeders and broadcasters (for fertilizers) are popularly used. However, every tractor owner necessarily doesn't have the implements. The number of mowers and balers is very small comparing the number of tractors.

(3) Only two interviewees have a combine harvester.

(4) Irrigation pumps and drip irrigation devices are usually combined for vegetables cultivation. Only 4 interviewees in Armavir Marz have the set.

(5) As same as irrigation pumps and drip irrigation devices, greenhouse holders are concentrated in Armavir Marz, except for 1 interviewee in Aragats-otn Marz. It seems that a combination of irrigation pump, drip irrigation device and green house is widely introduces for vegetable cultivation in Armavir Marz.

(6) Penetration rate of vehicles (truck or passenger car) is relatively high among the interviewees. There are 14 interviewees having either a truck or a passenger car. There are several interviewees to have more than 2 vehicles. It is interesting that all interviewees in Tavush Marz have a passenger car, though only they have a few number of farm machinery.

Table A-39 Number of Farmers Having Farm Machinery/Facility

Irrigation	Marz				Total Farmer	Total Unit
	Aragats-otn	Shirak	Armavir	Tavush		
Tractor	3	4	4	2	13	22
Seeder	1	4	3	2	10	10
Broadcaster (fertilizers)	1	2	3	0	6	6
Chemical sprayer	3	1	3	0	7	7
Harvester	0	1	1	0	2	2
Mower	0	1	0	0	1	1
Baler	1	0	0	0	1	1
Irrigation pump	0	0	4	0	4	5
Drip irrigation	0	0	4	0	4	5
Green house	1	0	5	0	6	8
Milking machine	0	0	0	0	0	0
Truck	2	3	2	1	8	11
Passenger car	2	2	2	5	11	15

13.Agricultural Technical Extension and Support Services in 2013

(1) There are few interviewees experienced agricultural technical support services in 2013. It seems that the existing government agricultural extension system is not fully functioning at field level.

(2) As for agricultural credit, there are 5 interviewees experienced in 2013. Out of the 5 interviewees, 2 are in Armavir Marz and 3 are in Tavush Marz. Though the credit users are located in only 2 Merzes, it is relatively a close supporting service to farmers.

Table A-40 Technical Extension or Support Services Experienced in 2013

Extension Service	Number of Farmers	
	Yes	No
Crop production	2	18
Vegetable production	1	19
Fruits/grape production	0	20
Animal husbandry	1	19
Food processing	0	20
Agricultural; credit	5	15

14.Problems of Farming

＜Crop Farming＞

(1) The most serious problem to interviewees is marketing issues, such as low selling prices, highly fluctuated selling prices and difficulty in finding reliable and reasonable buyers. The next serious problems are crop damages of insects and diseases, and high prices of farm inputs.

(2) Irrigation issues are categorized in the second group in the seriousness.

(3) Interviewees are not seriously concerned about agricultural technology and information issues including their own skill and knowledge of farming. They are also not seriously concerned about land issues, though they are not fully satisfied with the present situation.

(4) With respect to farm inputs issues, interviewees recognize that the high prices are more serious than the availability of the inputs.

(5) Many interviewees consider that access to agricultural credit is not a serious issue for them.

(6) There is no significant difference of farming issues between 4 Marzes according to answers from the interviewees. Unique farming issues of each Marz are summarized as follows.

a. Aragatsotn Marz

The interviewees recognize that access to agricultural credit is relatively serious comparing to the other Marzes

b. Shirak Marz

The interviewees recognize that small farmland and no good varieties of crops are relatively serious comparing to the other Marzes

c. Armavir Marz

The seriousness of marketing issues and high prices of farm inputs are remarkably high. Lack of man-power is also recognized seriously by many interviewees.

d. Tavush Marz

The interviewees don't care much about availability of farm inputs (easy access to Georgian market from Tavush Marz)

Table A-41 Seriousness of Problems and Constraints to the Farmers (Crop)
(the higher number is the more serious item)

Problems/Constraints	Seriousness Score				
	Aragats-otn	Shirak	Armavir	Tavush	Total
Technical information/services	4	3	3	5	**15**
Own skill & knowledge	0	0	1	2	**3**
Land size (need more land)	1	8	4	3	**16**
Land fertility	5	3	5	2	**15**
Salinity of land	1	2	2	1	**6**
Water shortage	4	3	5	3	**15**
Condition of irrigation facilities	6	6	7	4	**23**
Water conflict	6	6	6	4	**22**
No good varieties of crops	4	7	1	3	**15**
Pests & diseases	8	8	10	8	**34**
Availability of inputs	7	5	6	3	**21**
Inputs costs	4	6	9	8	**27**
Man-power	3	3	8	5	**19**
Availability of machinery/ mechanization service	4	5	3	3	**15**
Machinery/mechanization service costs	7	4	9	4	**24**
Conditions of storage facility	4	5	4	2	**15**
Means of transportation	3	2	4	2	**11**
Access to good market/buyers	4	6	10	7	**27**
Selling price is low	7	9	10	9	**35**
Market price stability (price fluctuation)	8	8	10	9	**35**
Access to credit	6	0	2	3	**11**

＜Livestock Farming＞

(1) As same as crop farming, interviewees recognize marketing issues, i.e. low selling prices and highly fluctuated selling prices are the most serious.

(2) The next serious problem recognized by interviewees is pests and diseases. However, they don't pay serious attention to availability of veterinary services (It may be possible that many interviewees breeding animals don't understand the importance of veterinary services, as majority of them are growing only chicken,)

(3) Many interviewees consider that the both availability and high prices are serious issues with regard to livestock inputs.

(4) High prices of animal feeds are also major issue for many interviewees. They also have a problem to secure grazing land. Stable feeding to livestock is also their serious problem.

Table A-42 Seriousness of Problems and Constraints to the Farmers (Livestock)
(the higher number is the more serious item)

Problems/Constraints	Seriousness Score				
	Aragats-otn	Shirak	Armavir	Tavush	Total
Technical information/services	2	3	0	0	**5**
Own skill & knowledge	0	0	0	1	**1**
Grazing land (no pasture)	2	6	1	1	**10**
Availability of feeds	1	3	0	1	**5**
Price of feeds	2	5	1	4	**12**
Water shortage (for animal)	2	0	0	1	**3**
Man-power	1	0	0	2	**3**
No good varieties of livestock	1	3	1	0	**5**
Pests & diseases	6	3	3	2	**14**
Availability of veterinary services	1	1	0	0	**2**
Availability of inputs	3	5	1	2	**11**
Inputs costs	3	5	0	3	**11**
Access to good market/buyers	2	6	0	3	**11**
Means of transportation	1	2	0	0	**3**
Selling price is low	5	8	0	5	**18**
Market price stability (price fluctuation)	4	7	0	5	**16**
Access to credit	4	2	0	1	**7**

15. Interested New/Advanced Farming Technology

(1) Interviewees are very interested in organic fertilizers/manure production, hygiene for food processing and new high performance varieties (crops & livestock).

(2) Many interviewees are not interested in the technologies related to livestock farming, may be due to less number of interviewees make an effort to breed animals. Interviewees are also not much interested in introduction of new crops/plants.

(3) Relatively many interviewees are interested in technologies related to food processing and marketing. It is probably caused by the present situation that many farmers have difficulty to market their products. However, none of interviewees in Armavir Marz regard the food processing in their strategy to improving their livelihood (See Table A-9).

(4) It is considered that many interviewees are more interested in adding value to their familiar crops than in introducing new crops to overcome the present difficulty in marketing.

(5) Water saving farming system/facility is also attached a higher value by interviewees.

Table A-43 Interested New/Advanced Farming Technology

Technology	Number of Answered Farmers			**Priority of the Interest**
	Very high	High	No need	
New crops/plants	5	3	9	**13**
New high performance varieties (crop & livestock)	11	4	6	**3**
Crop rotation system	9	3	8	**10**
Water saving farming system/facility	10	3	6	**5**
Appropriate water management technique (e.g. rotational irrigation)	9	4	7	**8**
Greenhouse cultivation	6	8	3	**9**
Organic fertilizer/manure production	12	6	8	**1**
Biological pest control of crops	8	3	3	**11**
Silage technology (fodder)	2	8	10	**14**
Biogas production	5	6	13	**12**
Cold storage system (e.g. for vegetables/fruits/meat)	9	5	3	**5**
Food processing/preservation technique	8	7	4	**5**
Hygiene for food processing	12	4	5	**2**
Packing including package design	11	2	6	**4**

Appendix-B WUA Workshop Outputs

1. The 1st Workshop: Khoy WUA Group No.1 (Date: July 24, 2014)

The first workshop was held in "Khoy" WUA with the WUA members from two communities of Aragats and Tsahkalanj in Armavir Marz. The outline of cropping in the communities is summarized in the following table.

Table B-1 Outline of Communities where the Participants belong (Khoy WUA No.1)

Name of Community	Irrigated Area by Crops (ha) in 2013							Register Farmland (ha)	% of Irrigation
	Wheat	Vegeta-bles	Grape	Orchard	Perennial grass	Others	Total		
Aragats	97.0	64.0	106.0	117.0	7.0	196.0	587.0	452.7	129.7
(%)	(16.5)	(10.9)	(18.1)	(19.9)	(1.2)	(33.4)	(100.0)	-	-
Tsahkalanj	73.0	33.0	55.0	16.0	11.0	290.0	477.0	312.0	152.9
(%)	(15.3)	(6.9)	(11.5)	(3.4)	(2.3)	(60.6)	(100.0)	-	-

Source: PIU

The both communities are located in the Ararat Plain on the borders of foothills, and irrigated by the Lower-Hrazdan canal. The communities get irrigation water to cover more than their registered farmland area in cadaster in 2013. Wheat, vegetables and fruits (including grape) are well combined while livestock farming is not developed in the both communities. Potato and fodder cereals may be the majority of other crops. Forcing cultivation of vegetables by greenhouses or tunnel (vinyl film) cultivation is widely introduced among farmers.

There were 21 participants in the workshop. During the discussion of the workshop a lot of different problems were discussed based on the theme of the workshop. In the first part of it, participants were asked to write on papers the problems according to the subject "Farm income is not enough". The farmers were encouraged to write as much problems as possible, and the participants were very active during this part. A problem tree as attached in Page B-5 of this report is made by arranging the problems raised by the participants for easy understanding the discussion.

After regrouping the problems raised, 10 major problem subjects were identified as follows:

1) **Marketing of products (the 2nd serious)**
2) **State extension & support (the 3rd serious)**
3) Irrigation system
4) Waste disposal to rivers
5) Water fee
6) **Shortage of water (the most serious)**
7) Credits
8) Soil fertility & quality of inputs
9) Seeds
10) Nuclear power plant

A lot of problems concerning the irrigation system were repeated by participants. The major issues mentioned were "irrigation water is not enough" and "bad condition of internal networks". A long discussion was held about the irrigation water which quantity is reducing year by year. They mentioned fishery industry as one of the main reasons for water quantity reduction, and there are big water losses because of bad conditions of internal networks. Thus, participants consented that the "**shortage of water"** was in the first position according to seriousness of their problems.

The quality of irrigation water was also raised as an essential problem as it is being contaminated day by day because of garbage thrown into a river which brings water to irrigation canals. They talked about waste disposal problem as a very serious one as having very negative effect on water quality. They mentioned during the discussion the river water had been very clean many years before.

Several participants pointed out that the fee of irrigation water is high, and they included it as a problem though some of the farmers did not agree with their opinion. In fact irrigation fee is just difficult to pay as the farming income is not enough to cover all its expenses.

The problem of "**products marketing"** took the second position according to its seriousness. The main problems in the marketing of products were low price, bad conditions of roads and difficulty for farmers to enter the market. If middlemen buy the products at farm-gate, the price is low, but taking the products to the market has still some difficulties connected with transportation and distance. If the market is far from the community, it takes time for farmers to reach there and also they should stay in the market whole day until they sell all their products. As a result, the farmers lose a valuable time for working in their field and also spend for fuel. Consequently, a net profit from the sales becomes equal to the sales at farm-gate (This explanation implies that middlemen don't make an unreasonable profit as many farmers envisaged comparing to their responsibility).

The participants expressed the view that there is a complete absence of state extension service in agriculture. The subject of "**state extension"** held the third position according to its seriousness. They

kept complaining that the Government should provide consultancy for the cultivation technology of crops concerning the exact use of fertilizers, agro-chemicals (fungicide, insecticide, etc.), their dosage and frequency necessary for each crop. Another issue of this group is agricultural machinery – the farmers mentioned that there were only several old tractors in the communities.

The problem of credits was also emphasized as an obstacle for farm management. The farmers complained that an interest rate of agricultural loans is very high, and the loans are provided to the farmers with a short term period. This problem was also presented with a request that the credit redemption condition should start from the harvesting period.

The problems of soil fertility were actively discussed nearly by every participant. Within this problem the price and quality of fertilizers were mentioned. They were talking much about infertility of soil which is getting worse year by year again comparing with the past years. Some people used also a word of “soil productivity” together with “soil fertility” just meaning that the yield is not enough or is not much.

The participants also talked about the ingredients of agro-chemicals which do not correspond with the content inside on their opinion. In some cases the chemicals does not give any effect – this was the participants’ concern during this part of discussion. Special attention was paid to the problem which any insecticides do not help to control tomato insects which are very common within last 2 - 3 years. These insects spoil the tomato production completely and the specialists from the Ministry of Agricultural still cannot find out a proper solution/chemical to abolish the insects.

Vegetable seeds were also considered a core problem in farming in these two communities. Farmers complained of the high price of vegetable seeds. They also mentioned that the quality of only imported seeds from Netherlands is good enough comparing with those imported from other countries or produced in Armenia. They said that none of authorized body inspected the seeds before marketing.

And the last subject discussed was based on the problem of nuclear power plant. The participants expressed the opinion that the Metsamor Nuclear Power Plant had negative effect on the quality of crop. They meant that the quality of products near the area of the Plant is reduced because of the radiation spread. Actually, the radiation effect on the crops has not been confirmed yet scientifically. This problem is more based on rumors than on their experience. The negative side of this problem is the fact that a part of consumers is being influenced by the rumors mainly, and this might cause the reduction of vegetables sales from these communities near the Nuclear Power Plant.

As an outcome of workshop we can conclude that the farmers are not satisfied with the income they receive out of farming. Mainly all of them were eager to express their complaints with a future hope to get some assistance. Some of them would prefer to get answers for some issues just on the spot.

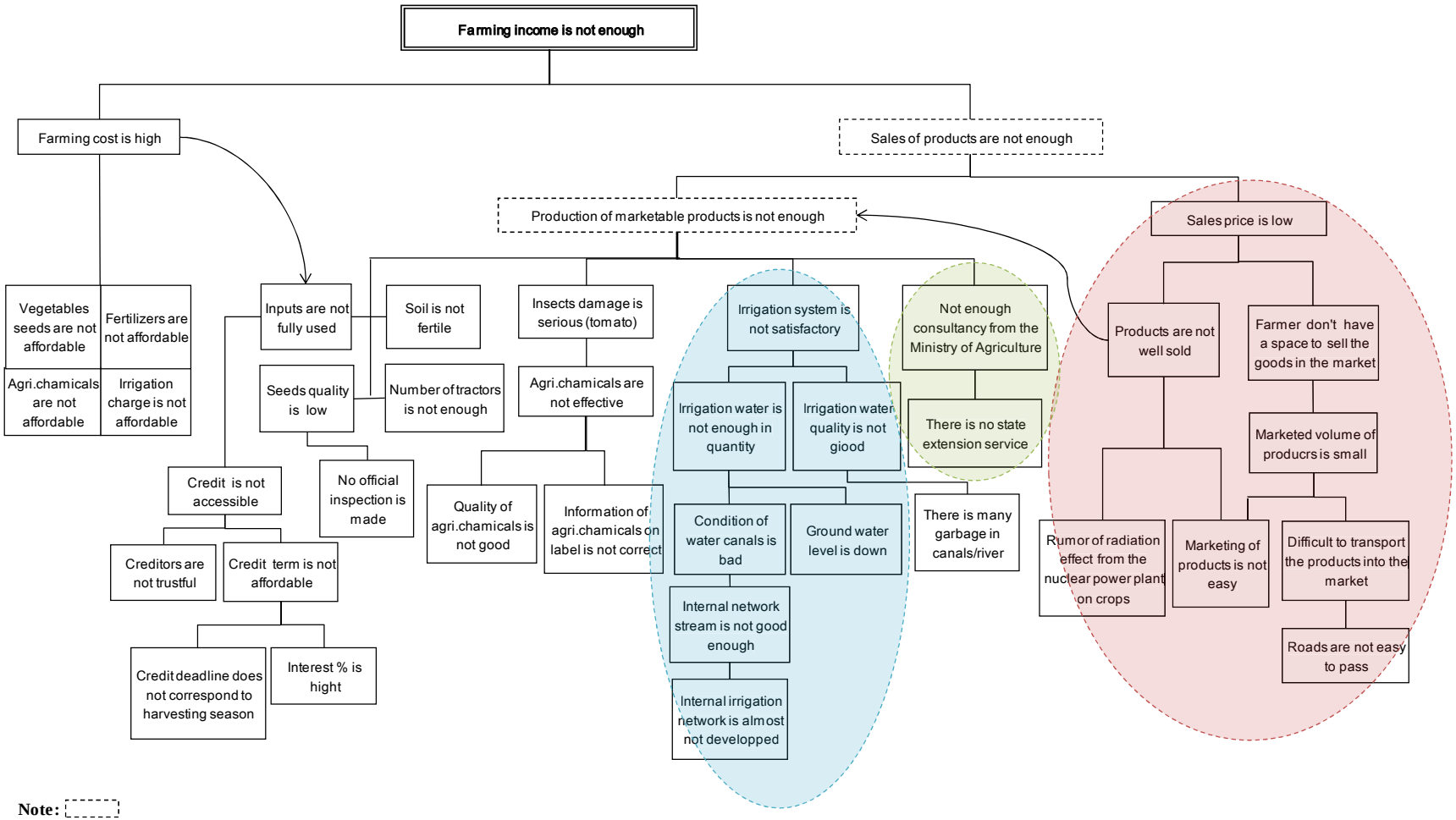
From the problems mentioned and the overall discussion, the impression was that farmers need a good organizer or a specialist who can provide technical consultancy for farming from the beginning of the

cultivation of crops up to harvesting. They mainly focused on irrigation and fertilizers/agro-chemicals problems as hindering crop cultivation which in fact directly effects on their farm income. Actually, all these problems are correlated to each other: low quality seeds - low quality fertilizers - infertile soil - low productivity x low selling price - low income and this circle is being continued for the next year as the low income does not give the possibility to hire tractors for soil cultivation, to buy good quality but expensive seeds, fertilizers/agro-chemicals, etc.

In the course of discussion in this workshop, problems connected with lack of government supports was highlighted both as requirement and as a wish of farmers. This kind of expectation to a sufficient degree of assistance from the Government might be a result of experience during the Soviet Union period when everything for the people was planned and the people were just implementers. Therefore, many farmers, especially in the elder generation, are not familiar with to plan and organize themselves.

Besides, it is necessary for the communities to have a cooperation mechanism in marketing the products, so that the community farmers don’t have overproduction of some crops, can gain an advantageous bargaining position, etc. May be farmers will be able to solve several marketing issues by themselves with proper communication and coordination among them.

Problem Tree of Workshop in Khoy WUA Group No.1



Note: ⬚

While it was not raised by the participants, the JICA team added for easy understanding the logic of problem tree

Figure B-1 Problem Tree of Khoy WUA Group No.1

2. The 2nd Workshop: Khoy WUA Group No.2 (Date: July 25, 2014)

The second workshop was held in "Khoy" WUA with the WUA member from two communities of Samaghar and Haytagh in Armavir Marz. The outline of cropping in the communities is summarized in the following table.

Table B-2 Outline of Communities where the Participants belong (Khoy WUA No.2)

Name of Community	Irrigated Area by Crops (ha) in 2013							Register Farmland (ha)	% of Irrigation
	Wheat	Vegeta-bles	Grape	Orchard	Perennial grass	Others	Total		
Samaghar	151.0	119.0	0.0	42.0	9.0	148.0	469.0	532.6	88.1
(%)	(32.2)	(25.4)	(0.0)	(9.0)	(1.9)	(31.6)	(100.0)	-	-
Haytagh	152.0	138.0	47.0	20.0	16.0	52.0	425.0	647.6	65.6
(%)	(35.8)	(32.5)	(11.1)	(4.7)	(3.8)	(12.2)	(100.0)	-	-

Source: PIU

The both communities are located in the Ararat Plain, and irrigated by the Lower-Hrazdan canal. The communities get irrigation water for less than their registered farmland area in cadaster, 88.1% and 65.6% respectively, in 2013. Vegetables may be major income source of farmers, while wheat is also widely grown. Fruits (including grape) and livestock farming are not popular. Forcing cultivation of vegetables by greenhouses or tunnel (vinyl film) cultivation is widely introduced among farmers. Many farmers also a drip-irrigation system by using small indivisual tube-well in combine with greenhouses.

There were 17 participants in the workshop. During the discussion of the workshop a lot of different problems were discussed based on the theme of the workshop. In the first part of it, participants were asked to write on papers the problems according to the subject "Farm income is not enough". The farmers were encouraged to write as much problems as possible and the participants were very active during this part. A problem tree as attached in Page B-10 of this report is made by arranging the problems raised by the participants for easy understanding the discussion.

After regrouping all the problems raised, 9 major problem subjects were identified as follows:

1) **Irrigation Water (the most serious)**
2) **Marketing of the products (the 2nd serious)**
3) Fertilizers
4) **Tractors/Agricultural machinery (the 3rd serious)**
5) Agro-chemicals
6) State extension & support
7) Waste disposal
8) Fee for gas and electricity
9) Seeds

"Irrigation water" was the main topic of the workshop and took the first position according to the seriousness. Much time was devoted to the irrigation problems discussion and analysis as there were many problems concerning to irrigation system. There is much water loss, the condition of internal network was very bad and ground water from tube-well is reducing year by year. Also many participants were complaining about irrigation canals which are covered with grasses and full of garbage. During the discussion, nearly all the farmers said that irrigation water was not enough. While the condition of internal network is a core issue of the irrigation problems, this problem becomes more serious since last five years when the ground water level was reducing continuously, according to the participants. Besides, the quality of irrigation water is not good. Farmers face the problem of waste disposal which has turned to be a serious issue. The farmers informed that people threw the major part of garbage into rivers, and it caused contamination of irrigation canals which are usually the end point of the rivers. Irrigation problems were considered major reasons of low crop production which directly causes an insufficient farm income.

There is another major problem connected to **"marketing of the products"**. Low price of the products is in contrast to high price of seeds. The vegetable seeds are sometimes more expensive than the price of harvested crops themselves. Selling price of products is low, while many products are left unsold, especially during the peak harvesting season. Bad road condition makes farmers difficult to transport the products to the market. The participants hope that farmers would have a chance to export their products to improve the situation. But they don't see any assistance from the Government to promote the export.

Another serious problem is defined as **"tractors or agricultural machinery"** which is in the third position in the problem subjects according to its seriousness. The participants concentrated a lot on the fact that soil cultivation is not done properly because of absence of tractors, and again this reflects on low soil productivity. In case of existing tractors they are too old. Farmers complained high prices of spare parts of the tractors, but mostly it is even difficult to find them for purchasing. While many farmers have no tractors, the rental fee is also not affordable for them. It is difficult for farmers to pay for it.

Next problem concerns to fertilizers and agro-chemicals. Again the complaints were focused on the high prices and low quality. They mentioned that without fertilizers and agro-chemicals, they could not have a good crop production. They complain that the government doesn't take proper measures to control quantity of fertilizers and agro-chemicals in the market.

State extension service– it is also serious problem concerning to agriculture. The Government should provide the farmers with information about new crops and also with agro-chemicals, fertilizers, seeds, etc. They also wish that the government should create some opportunities for exporting the products. The farmers were complaining about credits mentioning that there is no appropriate agriculture credit scheme. They need long-term credits with low interest rates; the percentage of credits is very high comparing with their income. "Many farmers are disappointed in agriculture and they leave the country to find another job in other countries"- this was a very common statement expressed by the participants as a result of absence of state extension and support.

The next problem subject is gas and electricity fees, which are high and getting higher and higher periodically. The high prices create difficulties in crop production as gas and electricity are used much during cultivation crops in greenhouses.

Another problem subject in the discussion was the quality and price of seeds. Seeds – the price is very high and the quality is bad. Farmers have an opinion that vegetable seeds which were imported from Netherlands had very good quality several years ago. But now, the quality of these seeds has been reduced and the price has become higher. Now only the seeds imported from Israel have good quality, but they are very expensive and farmers cannot afford themselves to buy the seeds with such high price.

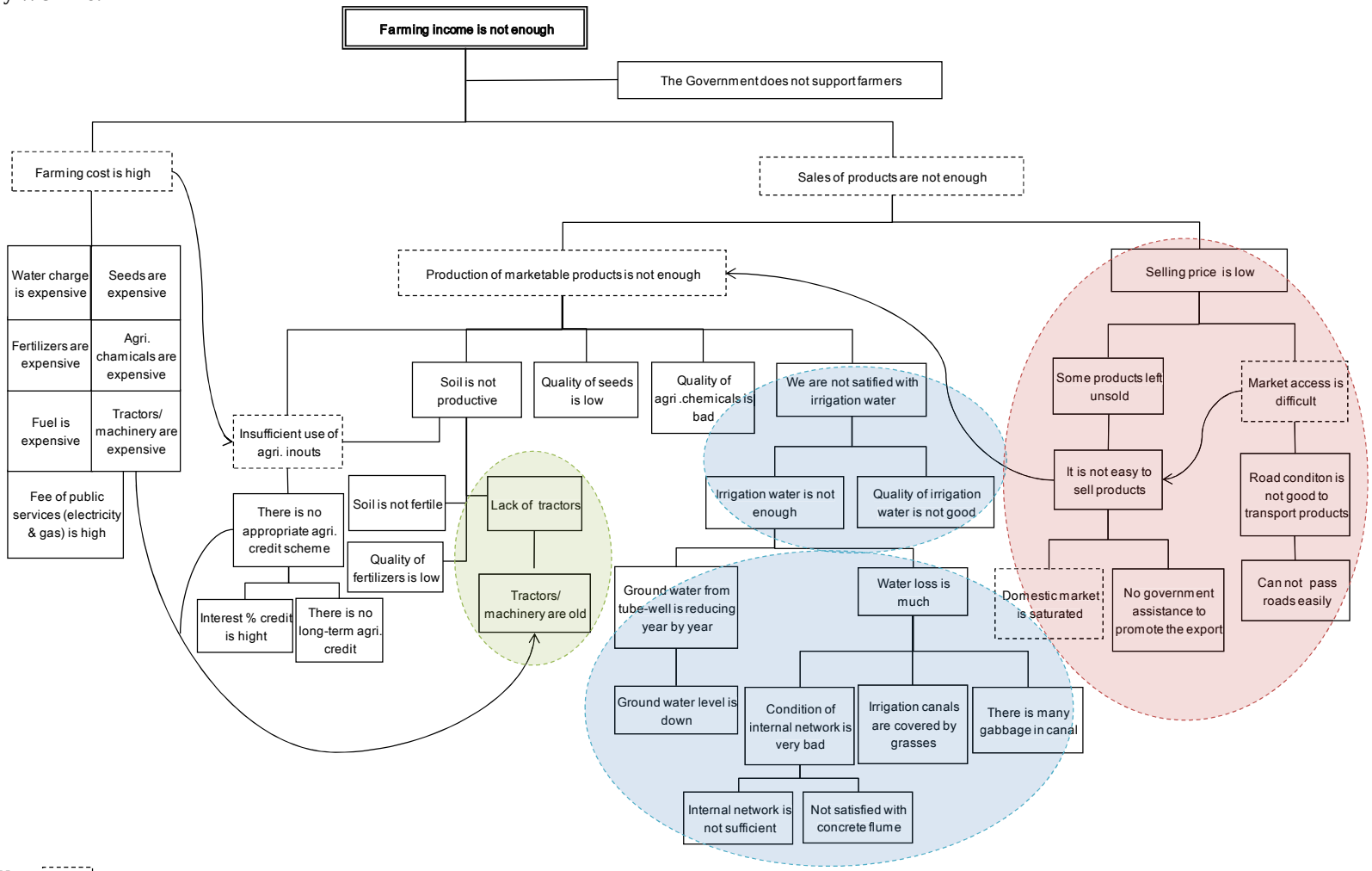
As a conclusion of this workshop we can understand that the problems are nearly the same as in the first workshops. Their complaints of high prices and quality of seeds, fertilizers, agro-chemicals, irrigation and tractors were considered the direct cause for having an insufficient inputs use and not enough income.

They also expressed much in complaints against the Government as dissatisfaction with the State extension service and support. The expectations to the Government concerned nearly all the problems mentioned above. Several opinions of the elder generation that everything has gone wrong after the collapse of the Soviet Union, and they have lost their hope and trust to get any kind of assistance from the authorities. On the other hand, they have abandoned the cooperative farming which prevailed during the Soviet Union time, and have completely shifted to individual farming to accommodate them to the new economy system.

The participants expressed a contradiction in their discussions during the workshop. They want to increase their crop production to increase their income on the one hand and have serious problem in marketing of their products on the other hand. They often face the problem of unsold products, especially in the peak harvesting season of vegetables. Seasonal overproduction of vegetables may be

an obvious core reason of the problem. However, nobody has a concrete idea to address the issue by themselves, while someone simply expresses a hope that the government should resume its intervention in marketing such as a state procurement with the fixed supporting price, or they will get good price if their products could be exported.

Khoy WUA No.2



Note: ⬚

While it was not raised by the participants, the JICA team added for easy understanding the logic of problem tree

Figure B-2 Problem Tree of Khoy WUA Group No.2

3. The 3rd Workshop: Aknalich WUA Group (Date: July 29, 2014)

The third workshop was held in "Aknalich" WUA with the WUA member from two communities of Taronik and Aratashen in Armavir Marz. The outline of cropping in the communities is summarized in the following table.

Table B-3 Outline of Communities where the Participants belong (Aknalich WUA)

Name of Community	Irrigated Area by Crops (ha) in 2013							Register Farmland (ha)	% of Irrigation
	Wheat	Vegeta-bles	Grape	Orchard	Perennial grass	Others	Total		
Taronik	18.0	94.0	3.0	8.0	51.0	112.0	286.0	404.9	70.6
(%)	(6.3)	(32.9)	(1.0)	(2.8)	(17.8)	(39.2)	(100.0)	-	-
Aratashen	168.0	305.0	67.0	13.0	32.0	66.0	651.0	723.8	89.9
(%)	(25.8)	(46.9)	(10.3)	(2.0)	(4.9)	(10.1)	(100.0)	-	-

Source: PIU

The both communities are located in the Ararat Plain, and should be irrigated mainly by pumped-up river water through the Aygr Lich canal. However, the WUA area has not received water though the canal since last 4 years. Then, farmers in the communities totally depend on ground water for irrigating their farmland at present, according to "Aknalich" WUA office. The communities get irrigation water for less than their registered farmland area in cadaster, 70.6% and 89.9% respectively, in 2013. Vegetables occupy the largest cropped area, while perennial grass (alfalfa) and wheat are the second in Taronik and Aratashen, respectuvely. Forcing cultivation of vegetables by greenhouses or tunnel (vinyl film) cultivation is very popular among farmers. Many farmers also have a drip-irrigation system by using small individual tube-well in combine with greenhouses. The drip-irrigation system technology was introduced by the Millennium Challenge, an American Cooperation Program; about 5 years go according to the participants.

There were 21 participants in the workshop. During the discussion of the workshop a lot of different problems were discussed based on the theme of the workshop. In the first part of it, participants were asked to write on papers the problems according to the subject "Farm income is not enough". The farmers were encouraged to write as much problems as possible and the participants were very active

during this part. A problem tree as attached in Page B-15 of this report is made by arranging the problems raised by the participants for easy understanding the discussion.

After regrouping all the problems raised, 8 major problem subjects were identified as follows:

1) Fertilizers and agro-chemicals
2) **Irrigation water (the most serious)**
3) **Marketing of the products (the 2nd serious)**
4) **Seeds price and quality (the 3rd serious)**
5) Tractors/Agricultural machinery
6) Soil fertility
7) State extension & support
8) Crop rotation

"Irrigation water" is the most serious problem subject. Nearly all participants mentioned irrigation as one of the most important problems which they are eager to be solved. There is shortage of irrigation water, and this problem leads to many other problems concerning to crop production. It is very difficult for farmers to have good products without stable irrigation water. The participants stressed that condition of internal networks was very bad. Because of the bad condition of internal networks, there are much losses of irrigation water. Consequently, quantity of irrigation water isn't enough. The issue is very crucial especially at the ending points of irrigation system where irrigation water does not reach to farmland. Farmers reported this issue to the Ministry of Agriculture and also to the Government, but still there isn't any answer or any support on this matter. The director of Aknalich WUA was also very concerned with this issue. This problem is partly caused by the fishery industry which is developed around these communities in Armavir Marz, since farmers in the communities much depend on ground water for supplemental irrigation. Even though farmers made a request to control the water use of the fishery industry, an effective measure has not been taken yet with some reasons, according to the participants.

"Marketing of the products" is the second serious problem subject. Selling price of crops is very low, instead of higher seeds price than the selling price of crops. The participants said that farmers had to work from early morning till late night to cultivate soil due to the low selling price of crops, but even so they don't have enough income from their crops at present (However, it seems that many farmers still keep a certain profit from vegetables even the profitability is getting worse). The participants hope a government support to marketing of their products in order to increase their income. They stressed that Armenian were very hardworking people, and they could grow various kinds of crops with more quantity if they were able to sell their entire product as they could during the Soviet Union time. There are some factories which buy the products from farmers, but they don't pay money to the farmers on due time. The farmers don't have agreements with the factories and cannot negotiate the price with them before selling. Moreover, the selling price to the factories is too low to get enough profit. While

the only accessible exporting country for them is Georgia, the export taxes and levies are very high. In the Soviet Union times, if a farmer had a land of 1000 m^2, he/she used to get more income than the present income from 1ha of land. Bad condition of rural roads also makes difficult transporting the products. This issue was discussed much as a hindering circumstance in the marketing of the products.

"Seeds price and quality" is the third serious problem subject. The main issue is the high price (of vegetable seeds) which is not affordable for many farmers in fact. Nearly all the farmers are complaining about this issue. And the quality of seeds, even in case of high price, is not good enough. So, the productivity of crops is low. Without having good seeds farmers can't have high crop production in good quality. As a result, their income won't be enough. The farmers want a state support for solving this problem.

In the other concerned problem subject were about fertilizers and agro-chemicals. The price of the inputs is not affordable to the farmers. Farmers had also large crop losses because of bad quality and suspicious origin of fertilizers and agro-chemicals sold in the market in recent years. The low quality of fertilizers and agro-chemicals has a negative influence on crop production. In some cases they are out of date and do not give any effects to the crop. There were also farmers who complained a special disease of tomato for which they haven't known any protection measures yet. Agro-chemicals which are offered by the Government do not help to overcome the disease, and they still look for a new treatment method. Because of this disease people have started to shift tomato cultivation to other crops.

The Government imports a certain quantity of inspected fertilizers from abroad, and sells them through an authorized marketing channel for supporting farmers. Some farmers say that farmers who have many hectares of land much enjoy the government fertilizers, though the government support is helpful to all farmers. Fertilizers which are sold by the Government are limited in quantity, and also the payment for them should be made in cash at once which is a difficulty for many farmers. Farmers would prefer to have some crediting system for buying fertilizers and agro-chemicals.

Tractors/agricultural machinery are another problem subject which hinders the development of agriculture in the communities. The farmers are willing to have appropriate agricultural machinery by themselves. Many of them, however, should hire machinery from villages nearby, and the rental fee is not affordable. This is a very essential issue to farmers, but the government doesn't pay much attention on this matter. Number of tractors in the communities is not enough. Moreover, the existing tractors and other machinery are so old. Even though they are being out of order very frequently, farmers haven't enough money for buying new spare parts for them. Because of the lack of machinery there are many hectares of land which are left uncultivated. The fuel price is also very high and it hinders full operation of tractors.

Soil fertility is one of problems which were discussed during the workshop. Actually, the soil becomes infertile in recent years. This degradation of soil is increasing continuously. If the Government does not

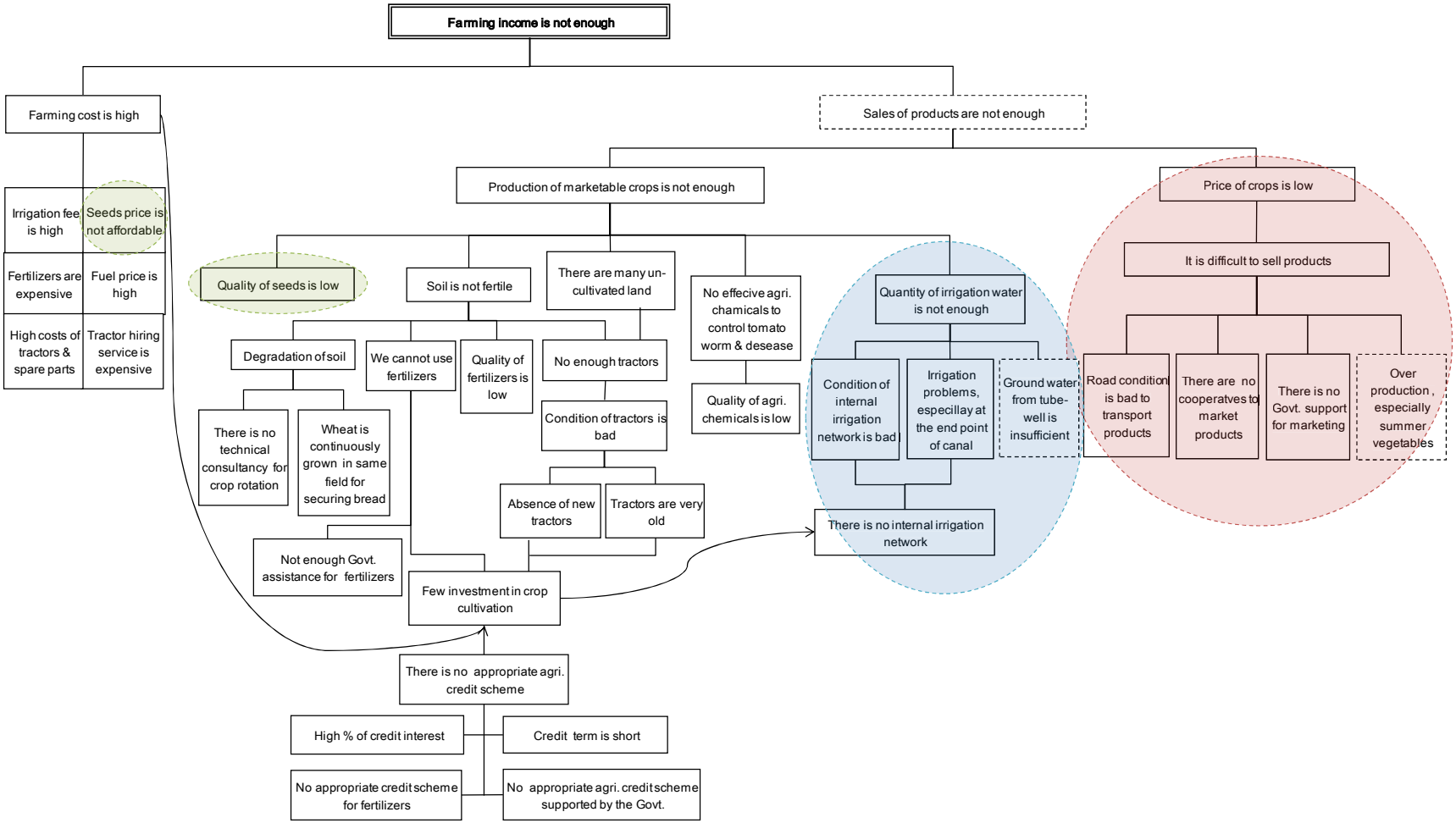
provide proper consultancy on this issue or does not take special steps to solve the problem, it will cause big losses to the crops yield.

Concerning to the soil degradation, we came across with an issue of crops rotation in the workshop. This problem was mainly discussed while confirming a cropping calendar of the communities. During discussion about the crop rotation, farmers focused on the problem that they should keep wheat cultivation every year in order to secure their bread. If they grow another crop, for example vegetables, they can't earn as much money as they need to buy the bread, according to their explanation. Though they do not have enough yield of wheat by a continuous cultivation, they keep growing wheat. The participants also say that they need a technical consultancy to introduce a proper crop rotation in their farm management.

In the problem subject of state extension and support, there were a lot of discussions about an agricultural credit. It was mentioned that there is no appropriate agricultural credit scheme supported by the Government. The banks provide loans to farmers with short term redemption which is not suitable for them. The interest rates are also high. They wish to have a more friendly credit scheme to them with low percentage of interest and long redemption period. As mentioned above, farmers need a consultancy service for effective use of fertilizers, agro-chemicals, tractors, etc. They expect a comprehensive technical support concerning farm management. The ones having greenhouses wanted to have a support concerning an innovated greenhouse farm management.

As an outcome of this workshop we understood that the problems were nearly the same as in other workshops. Here we had farmers who were very anxious about irrigation problem as their lands were located in the ending points of the irrigation scheme, and they didn't get water at all. Everybody pointed out the importance of irrigation water for the cultivation of crop. Lots of complaints were concerning to the high prices of inputs and low price of the products. As same as the previous workshop, the participants made a contradictory discussion in that they wanted to increase their production on the one hand, they complained marketing issues about low price and unsold products on the other hand. Then, they simply expect a Government intervention in marketing as the Soviet Government did, without understanding what the real marketing under the free-market system is.

Aknalich WUA



Note: ⬚

While it was not raised by the participants, the JICA team added for easy understanding the logic of problem tree

Figure B-3 Problem Tree of Aknalich WUA Group

4. The 4th Workshop: Yeghvard WUA Group (Date: July 30, 2014)

The fourth workshop was held in "Yeghvard" WUA with the WUA member from Kasaak community and Proshyan community in Kotak Marz. The outline of cropping in the communities is summarized in the following table.

Table B-4 Outline of Communities where the Participants belong (Yeghvard WUA)

Name of Community	Irrigated Area by Crops (ha) in 2013							Register Farmland (ha)	% of Irrigation
	Wheat	Vegeta-bles	Grape	Orchard	Perennial grass	Others	Total		
Kasaak	68.0	20.0	5.0	55.0	42.0	110.0	301.0	634.0	47.5
(%)	(22.6)	(6.6)	(1.7)	(18.3)	(14.0)	(36.9)	(100.0)	-	-
Proshyan	4.0	7.0	63.0	139.0	104.0	19.4	336.4	1,139.7	29.5
(%)	(1.2)	(2.1)	(18.7)	(41.3)	(30.9)	(5.8)	(100.0)	-	-

Source: PIU

The both communities are located at foothills of Arayiler mountain, and irrigated by the Arzni Branch canal. The commnities get irrigation water far less than their registered farmland area in cadaster, 47.5% and 29.5% respectively, in 2013. Wheat, Fruits (incluging grape) and Livestock are well combined in Kasaak community, while wheat is not popluar in Proshyan community. Comparing to the other 3 groups participated in the previous workshops, the communities much depend on fruits production and livestock farming, and vegetables growing is not so popular except for own consumption purpose.

There were 23 in participants in the workshop. During the discussion of the workshop a lot of different problems were discussed based on the theme of the workshop. In the first part of it, participants were asked to write on papers the problems according to the subject "Farm income is not enough". The farmers were encouraged to write as much problems as possible and the participants were very active during this part. A problem tree as attached in Page B-20 of this report is made by arranging the problems raised by the participants for easy understanding the discussion.

After regrouping all the problems raised, 10 major problem subjects were identified as follows:

1) Irrigation system (the 2nd serious)

2) **Soil fertility (the 3rd serious)**
3) **Marketing of the products (the 3rd serious)**
4) Less inputs/Financial problems
5) Insurance
6) Tractors
7) New technologies
8) Fertilizers/Agro-chemicals
9) **Seeds price and quality (the most serious)**
10) Loans/Credits

This was the fourth and the last workshop, and contents of the discussions were a little bit different from the other three workshops due to farming condition of the target communities, while contents of problems raised by the participants were basically as same as the other workshops.

In this group, **"seeds price and quality"** was the first critical problem subject. The main problems were again here high price and bad quality of seeds. The participants mentioned that the wheat seeds imported from Russia during last three years were very bad in quality. There are many seeds imported from other countries, but they are not appropriate to the conditions/soil of Armenia, according to the participants. The farmers really need seeds in good quality for wheat and also for vegetables.

"Irrigation system" was the second serious problem subject. Almost all the participants were complaining about irrigation water**.** Ground water isn't used properly and internal canal networks are in very bad condition which causes much water loss. In Proshyan community the irrigation water quantity is very low. The cultivated crops and orchards are dried because of less irrigation. The irrigation water is too less to cultivate lands. This is a priority problem and the farmers need it to be solved very quickly. Many participants said that they want to grow grapes and fruits much if they could get enough irrigation water.

The next serious problem subject was connected with **"soil fertility"**. The participants stressed that the soil in this area is infertile and the productivity is low. Also, they mentioned that irrigation water was easily absorbed into soil due to the nature of soil structure. The water retaining capacity of soil is very poor in this area.

The problem with tractors was similar to the other communities in the previous workshops. The complaints are that the existing tractors are very old, and it's very difficult to cultivate soil properly without good conditioned machinery. They also mentioned about some specialized tractors for cultivating orchards.

Concerns to **"marketing of the products"** which was also the third serious problem subject in the communities, we see that again sales of products were difficult. Consequently, farmers cannot manage

to cover all the farming costs with their farm income, as the cultivation expenses which include fee for electricity/gas, fuel and various inputs exceed the farm income.

Comparing with times of the Soviet Union, production of grape which is a very common crop in this area has reduced much due to lack of good buyers, i.e. processing factories. Now, there is only one wine factory nearby and almost of the entire grape produced is sold to this factory. Though farmers need a lot of works for grape cultivation, the price is low at present. Therefore, many people have shifted from grape to wheat, as wheat is easy to grow and does not demand much water. Moreover, farmers often cannot sell produced crops completely. There are no means to keep/storage the crops, and investment for facilities to process the unsold crops is not enough as well. Farmers wished to have more plants for drying fruits, especially for apricot and plum. Many participants also stressed that rural road was in a bad condition to transport their products.

The participants also discussed an issue of introducing new technologies – dripping system which can be in new orchards because it won't be possible to install in old orchards. They also pointed out the need to change irrigation system from pump station irrigation to gravity flow.

During the regrouping problems of fertilizers and agro-chemicals, the quality of agro-chemicals and price of fertilizers were discussed much. There were also common opinions that many agro-chemicals have been out of date and do not have any effect at all.

In this workshop, a problem of insurance was also stressed. They complained that there were no anti-hailing systems in their communities, and the farmers didn't have any insurance preparing for the natural disaster. In general, there isn't any kind of agricultural insurance at present. And the last problem subject discussed in the workshop was agricultural credits. The problems were the same as the previous workshops that the interest rates are high and the redemption period is short in general. There was one participant who mentioned that a credit is provided with foreign currency (He is actually afraid of an additional burden due to the devaluation of Armenian currency).

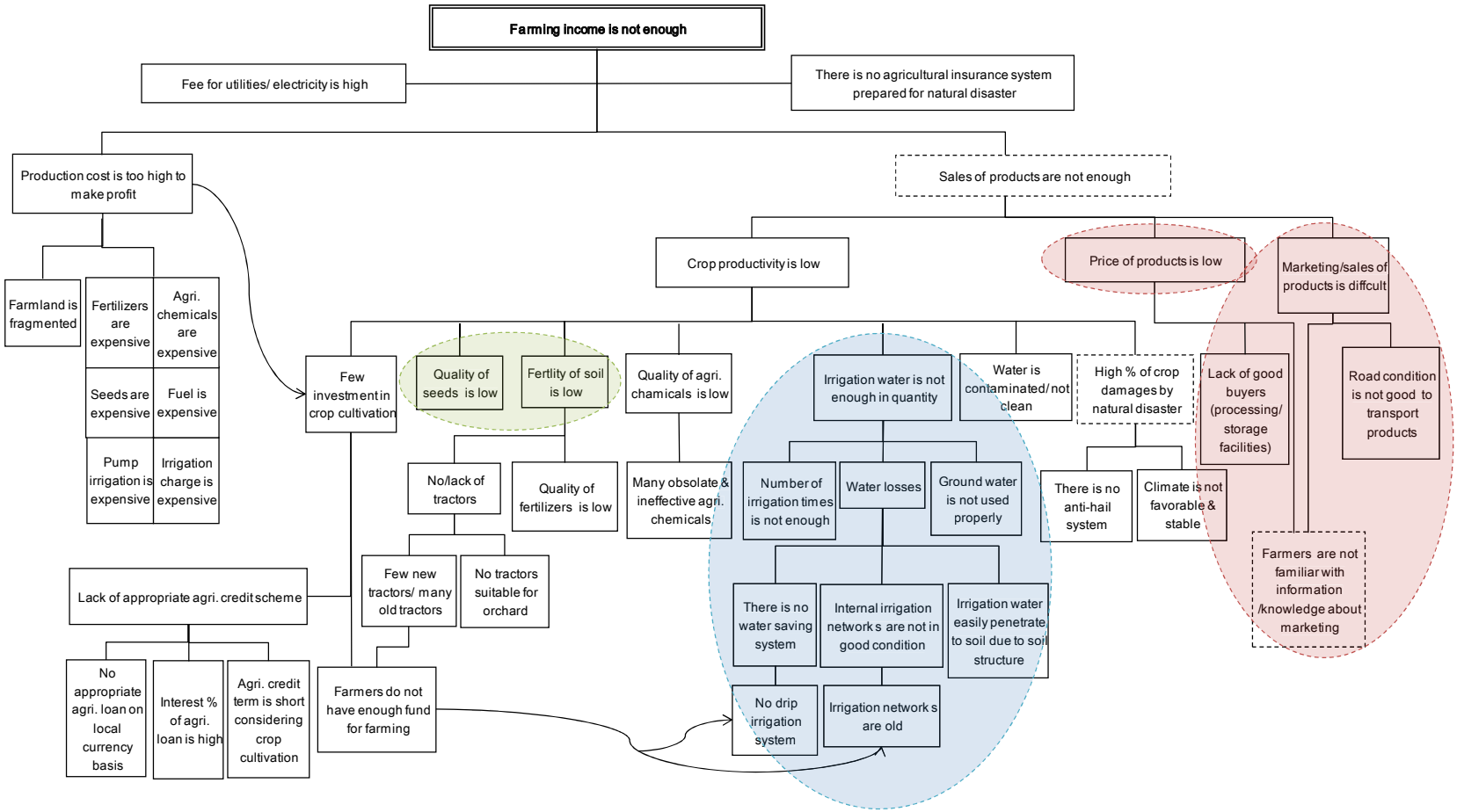
It was very interesting that the participants was not strongly concerned to irrigation issues comparing to the other 3 groups, even though this group suffered much from the shortage of irrigation water according to the collected information. It may be because of farming condition in the communities, and many farmers manage their farming based on the assumption that irrigation water is always not enough. Their interest in farming is much on fruits (including grape) growing and livestock, instead of vegetables, probably due to their experience and agro-environmental condition of the communities.

As same as the other groups, marketing is one of the serious issues. However, it seems that nobody has a concreate idea to overcome the present situation other than restoring a similar system in the Soviet Union time with nostalgic eyes, also as same as the other groups. Though it is unfair for farmers that they get the much blame for such situation, they should understand that they will change their attitude on marketing by themselves to address the present issues.

<Note>

There are several participants who grow crops in the site of Yeghvard Reservoir at present. According to them, there are about 10 - 15 farmers to grow crops, mainly wheat, every year in about 20 ha of land in the site. They clearly mentioned that all farmers recognize the present cultivated land in the site is under property of the Government, and are ready to leave from the land without claiming their rights after starting the construction of Yeghvard Reservoir, since they are expecting benefit from the reservoir. Actually, they have only marginal production from the land, because of poor soil condition after removing fertile surface soil for the previous dike construction.

Yeghvard WUA



Note: ⬚

While it was not raised by the participants, the JICA team added for easy understanding the logic of problem tree

Figure B-4 Problem Tree of Yeghvard WUA Group

5. Cropping Calendar

Table B-5 Crop Calendar in Yeghvard Irrigation Project area

(based on outputs from WUA workshops)

Crop	Month												Yield (ton/ha)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wheat (Hilly area)													2.0-2.5
Irrigation													
Wheat (Plain area)									3.5				
Irrigation													
Barley								1.5-2.0					
Irrigation													
Alfalfa (6 -7 years)													
Irrigation						(6 times)							
Potato (1st & 2nd)													
Irrigation				(5 - 6 times)			(7 - 10 times)						
Cabbage (1st Tunnel)										50.0-60.0			
Irrigation				(every 7 - 10 days)								Seedling	
Cabbage (2nd)									70.0-80.0				
Irrigation			Seedling	(every 7 - 10 days)									
Cabbage (3rd)													
Irrigation				Seedling	(every 7 - 10 days)								
Cucumber (1st)									20.0-30.0				
Irrigation					(every 2 days)								
Cucumber (2nd)													
Irrigation							(every 2 days)						
Tomato (Green house)										100.0			
Irrigation	Seedling		(Drip irrigation)										
Tomato (Open)													
Irrigation				Seedling	(every 3 - 4 days)								
Papper (Green house)	Same as Tomato											50.0	
Papper (Open)	Same as Tomato											35.0	
Egg plant (Green house)	Same as Tomato												40.0-50.0
Egg plant (Open)	Same as Tomato											35.0-	40.0
Onion													
Irrigation				(about 20 times)						Seedling			
Water melon									60.0				
Irrigation				Seedling	(every 3 days)								
Strawberry (Tunnel) (2-3 years)							Planting						15.0-20.0
Irrigation				(every 2-3 days)					(20 times)				
Herbs (Green house & Open)													
Irrigation					(2 - 3 times /month)								
Apple (about 30 years)													
Irrigation					(12 times new trees, 7 times adult trees)								
Grape (50-60 years)													
Irrigation					(12 times new trees, 6 times adult trees)								
Apricot (about 60 years)													20.0
Irrigation						(5 - 6 times)							

Appendix-C　Supporting Information of Agriculture

Appendix C-1 National Land Use (2008-2012)

	Land Use Type	2008	2009	2010	2011	2012
Area (x 1,000 ha)						
1	Agricultural Land	**2,121.2**	**2,120.3**	**2,100.9**	**2,077.0**	**2,052.4**
	(1) Arable land	450.4	449.4	448.5	449.2	448.4
	(2) Perennial crops land	31.6	32.6	32.9	33.0	33.4
	(3) Hayfield	127.3	127.3	127.1	128.3	121.6
	(4) Pastures	1,117.1	1,116.6	1,104.3	1,067.2	1,056.3
	(5) Other	394.8	394.4	388.1	399.3	392.7
2	Forest land	**369.8**	**369.8**	**369.1**	**343.1**	**334.2**
3	Settlement & industrial use	**180.4**	**181.0**	**183.8**	**185.2**	**185.2**
4	Special nature protected territories	**229.7**	**229.9**	**249.4**	**298.0**	**331.9**
5	Others	**73.2**	**73.3**	**71.1**	**71.0**	**70.6**
6	Total	**2,974.3**	**2,974.3**	**2,974.3**	**2,974.3**	**2,974.3**
Area (%)						
1	Agricultural Land	**71.3**	**71.3**	**70.6**	**69.8**	**69.0**
	(1) Arable land	15.1	15.1	15.1	15.1	15.1
	(2) Perennial crops land	1.1	1.1	1.1	1.1	1.1
	(3) Hayfield	4.3	4.3	4.3	4.3	4.1
	(4) Pastures	37.6	37.5	37.1	35.9	35.5
	(5) Other	13.3	13.3	13.0	13.4	13.2
2	Forest land	**12.4**	**12.4**	**12.4**	**11.5**	**11.2**
3	Settlement & industrial use	**6.1**	**6.1**	**6.2**	**6.2**	**6.2**
4	Special protected territories	**7.7**	**7.7**	**8.4**	**10.0**	**11.2**
5	Others	**2.5**	**2.5**	**2.4**	**2.4**	**2.4**
6	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Statistical Yearbook of Armenia, National Statistical Service of RA

Appendix C-2 Population in Armenia (2001-2013)

Year	**2001**	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	**2012**
Population (x1000)	**3215.3**	3212.9	3210.3	3212.2	3215.8	3219.2	3222.9	3230.1	3238.0	3249.5	3262.6	**3021.4**

Note: Only data in 2001 and 2012 are based on the population census. Other data are estimated.

Source: Statistical Yearbook of Armenia, National Statistical Service of RA

Appendix C-3 The number of agricultural households and agricultural lands by Marzes (As of 1st January, 2006)

Marz	Farm-household	Agricultural lands (ha)	Including (ha)				Average land/farm-household (ha)
			Annual crops	Perennial plants	Grass land (harvested)	Pasture (grazing)	
Yerevan	10	122	80	30	12	-	12.20
Aragatsotn	37,165	58,159	47,710	4,956	2,351	3,142	1.56
Ararat	53,475	33,110	23,534	8,190	816	570	0.62
Armavir	50,347	47,677	34,503	12,575	599	-	0.95
Gegarkunik	52,130	83,979	63,898	119	17,032	2,930	1.61
Lori	32,559	63,732	41,222	1,029	21,481	-	1.96
Kotayk	37,620	41,649	30,142	3,946	5,839	1,722	1.11
Shirak	28,156	66,609	63,780	25	2,804	-	2.37
Syunik	13,034	40,101	35,691	789	3,621	-	3.08
Vayots Dzor	12,827	16,052	12,872	1,002	2,168	10	1.25
Tavush	21,953	34,399	21,831	4,539	5,623	2,406	1.57
Total	**339,276**	**485,589**	**375,263**	**37,200**	**62,346**	**10,780**	**1.43**

Source: The Ministry of Agriculture, RA

Appendix C-4 Harvested Area of Major Crops (ha), 2000 & 2008-2012

Crop	2000	2008	2009	2010	2011	2012
Wheat	106,440	92,810	88,530	86,574	77,806	93,476
Barley	47,100	66,260	66,511	60,954	67,873	65,135
Other cereals	3,045	10,935	8,973	8,138	13,159	11,661
Pulses	2,024	2,199	2,053	1,874	1,952	2,005
Potatoes	34,202	34,298	31,998	28,326	28,665	31,243
Tomatoes	5,588	6,257	6,231	6,517	6,837	6,260
Watermelons	3,386	5,446	6,163	4,470	5,764	5,128
Cabbages and other brassicas	3,083	3,418	3,070	3,217	3,453	3,498
Cucumbers and gherkins	2,500	2,339	2,549	2,237	2,548	2,360
Onions, dry	1,946	2,487	2,085	1,869	1,961	1,901
Other vegetables	6,924	9,716	9,978	9,618	10,114	10,990
Sugar beet	50	2,000	600	1,700	3,600	4,000
Tobacco, unmanufactured	2,528	170	297	417	614	667
Forage crops	190,670	200,742	200,866	200,622	200,820	200,701
Grapes	14,571	14,390	14,292	14,613	14,478	15,723
Apples	5,959	8,298	8,811	9,321	8,962	9,583
Apricots	3,300	8,140	7,808	7,928	7,739	8,221
Peaches and nectarines	3,267	4,269	4,283	4,317	4,509	4,434
Other fruits	9,111	9,501	9,714	9,856	9,865	10,730
Tree-nuts	NA	1,462	1,557	1,520	1,530	1,530

Source: FAOSTAT

Appendix C-5 Production of Major Crops (ton), 2000 & 2008-2012

Crop	2000	2008	2009	2010	2011	2012
Wheat	181,561	225,734	198,080	183,464	224,082	243,130
Barley	32,944	149,091	145,141	118,574	178,226	170,118
Other cereals	6,314	34,357	25,856	19,916	33,162	37,801
Pulses	3,863	6,171	5,783	4,469	5,201	5,063
Potatoes	290,260	648,562	593,551	481,956	557,322	647,201
Tomatoes	143,667	293,784	278,582	251,916	275,470	265,174
Watermelons	52,844	182,159	216,101	132,506	180,879	205,078
Cabbages and other brassicas	51,540	122,702	115,889	114,279	128,459	131,785
Cucumbers and gherkins	30,000	81,819	80,944	63,282	73,678	74,470
Onions, dry	31,328	61,449	50,416	38,282	40,576	44,527
Other vegetables	119,180	265,644	294,044	239,915	269,033	333,107
Sugar beet	800	30,000	10,000	26,000	56,500	60,000
Tobacco, unmanufactured	4,577	538	1,055	1,376	2,386	1,817
Forage crops	2,558,400	2,518,263	2,517,820	2,512,518	2,510,218	2,512,737
Grapes	115,841	185,832	208,649	222,905	229,589	241,429
Apples	23,230	117,199	120,844	56,487	77,602	110,289
Apricots	36,720	8,308	8,064	7,671	4,936	7,619
Peaches and nectarines	26,800	41,651	57,883	23,805	43,824	63,528
Other fruits	41,761	75,824	72,849	40,545	64,837	81,805
Tree-nuts	NA	4,471	4,333	4,300	4,540	4,740

Source: FAOSTAT

Appendix C-6 Yield of Major Crops (ton/ha), 2000 & 2008-2012

Crop	2000	2008	2009	2010	2011	2012
Wheat	1.71	2.43	2.24	2.12	2.88	2.60
Barley	0.70	2.25	2.18	1.95	2.63	2.61
Other cereals	2.07	3.14	2.88	2.45	2.52	3.24
Pulses	1.91	2.81	2.82	2.38	2.66	2.53
Potatoes	8.49	18.91	18.55	17.01	19.44	20.72
Tomatoes	25.71	46.95	44.71	38.66	40.29	42.36
Watermelons	15.61	33.45	35.06	29.64	31.38	39.99
Cabbages and other brassicas	16.72	35.90	37.75	35.52	37.20	37.67
Cucumbers and gherkins	12.00	34.98	31.76	28.29	28.92	31.56
Onions, dry	16.10	24.71	24.18	20.48	20.69	23.42
Other vegetables	17.21	27.34	29.47	24.94	26.60	30.31
Sugar beet	16.00	15.00	16.67	15.29	15.69	15.00
Tobacco, unmanufactured	1.81	3.16	3.55	3.30	3.89	2.72
Forage crops	13.42	12.54	12.53	12.52	12.50	12.52
Grapes	7.95	12.91	14.60	15.25	15.86	15.36
Apples	3.90	14.12	13.72	6.06	8.66	11.51
Apricots	11.13	1.02	1.03	0.97	0.64	0.93
Peaches and nectarines	8.20	9.76	13.51	5.51	9.72	14.33
Other fruits	4.58	7.98	7.50	4.11	6.57	7.62
Tree-nuts	NA	3.06	2.78	2.83	2.97	3.10

Source: FAOSTAT

Appendix C-7 Harvested Area and Volume of Water for Irrigation (2008-2012)

	2008	2009	2010	2011	2012
Harvested area of major crops (x 1000ha)	485.1	476.4	464.1	472.2	489.2
Volume of the supplied water for irrigation (million m3)	576.7	412.0	396.5	415.3	472.1

Source: FAOSTAT (harvested area)

State Water Committee of the Ministry of Territorial Administration (irrigation)

Appendix C-8 Production of Major Crops by Marzes (Ave. of 2009-2013)

Marzes	Cereals		Potato		Vegetables		Melons		Grape		Fruits and Berries (Productive Age)		Forage crops	
Planted Area	**(ha)**	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**
Yerevan	145	0.1	84	0.3	311	1.3	22	0.4	612	4.1	1,320	4.0	104	0.2
Aragatsotn	23,471	14.1	1,575	5.2	915	3.7	166	3.1	1,488	9.9	5,212	15.7	6,779	10.9
Ararat	5,223	3.1	836	2.8	6,416	26.2	1,498	27.9	4,659	31.0	6,456	19.4	5,813	9.3
Armavir	6,563	3.9	1,355	4.5	8,592	35.0	3,573	66.5	5,552	36.9	5,647	17.0	7,247	11.6
Gegharkunik	42,866	25.8	13,962	46.3	1,854	7.6	0	0.0	0	0.0	1,382	4.2	13,572	21.8
Lori	9,632	5.8	3,902	12.9	1,370	5.6	8	0.1	64	0.4	2,219	6.7	8,537	13.7
Kotayk	10,521	6.3	794	2.6	1,289	5.3	0	0.0	302	2.0	4,010	12.1	2,222	3.6
Shirak	37,416	22.5	3,879	12.9	1,428	5.8	0	0.0	0	0.0	455	1.4	9,653	15.5
Syunik	19,810	11.9	1,709	5.7	971	4.0	0	0.0	185	1.2	2,412	7.3	5,379	8.6
Vayots Dzor	2,646	1.6	180	0.6	424	1.7	17	0.3	834	5.5	1,900	5.7	1,079	1.7
Tavush	8,004	4.8	1,906	6.3	954	3.9	91	1.7	1,339	8.9	2,226	6.7	1,946	3.1
Total	**166,297**	**100.0**	**30,182**	**100.0**	**24,524**	**100.0**	**5,375**	**100.0**	**15,035**	**100.0**	**33,239**	**100.0**	**62,331**	**100.0**
Production	**(ton)**	**(%)**	**(ton)**	**(%)**	**(ton)**	**(%)**	**(ton)**	**(%)**	**(ton)**	**(%)**	**(ton)**	**(%)**	**(ton)**	**(%)**
Yerevan	407	0.1	1,537	0.3	3,989	0.5	324	0.2	3,623	1.6	4,818	1.7	1,541	0.4
Aragatsotn	58,572	13.6	36,423	6.2	28,014	3.6	6,217	3.3	12,890	5.6	50,476	17.6	37,570	9.3
Ararat	20,047	4.7	25,816	4.4	278,164	35.7	61,753	32.8	96,160	42.1	79,533	27.7	102,288	25.3
Armavir	21,437	5.0	41,626	7.1	302,470	38.8	117,901	62.5	97,589	42.7	62,877	21.9	111,556	27.5
Gegharkunik	118,766	27.7	269,116	45.9	56,797	7.3	0	0.0	0	0.0	23,151	8.1	41,845	10.3
Lori	22,070	5.1	50,595	8.6	17,932	2.3	45	0.0	152	0.1	4,623	1.6	29,202	7.2
Kotayk	19,657	4.6	15,948	2.7	23,114	3.0	0	0.0	449	0.2	19,557	6.8	11,878	2.9
Shirak	97,180	22.6	91,718	15.6	36,363	4.7	0	0.0	0	0.0	4,401	1.5	30,725	7.6
Syunik	40,892	9.5	28,798	4.9	16,439	2.1	1	0.0	1,045	0.5	14,136	4.9	20,504	5.1
Vayots Dzor	5,457	1.3	3,074	0.5	6,547	0.8	289	0.2	4,154	1.8	8,677	3.0	7,679	1.9
Tavush	24,880	5.8	21,747	3.7	9,053	1.2	1,999	1.1	12,617	5.5	15,051	5.2	10,304	2.5
Total	**429,365**	**100.0**	**586,398**	**100.0**	**778,882**	**100.0**	**188,529**	**100.0**	**228,679**	**100.0**	**287,300**	**100.0**	**405,092**	**100.0**
Yield	**(ton/ha)**	**-**	**(ton/ha)**	**-**	**(ton/ha)**	**-**	**(ton/ha)**	**-**	**(ton/ha)**	**-**	**(ton/ha)**	**-**	**(ton/ha)**	**-**
Yerevan	2.81	-	18.30	-	12.83	-	14.73	-	5.92	-	3.65	-	14.82	-
Aragatsotn	2.50	-	23.13	-	30.62	-	37.45	-	8.66	-	9.68	-	5.54	-
Ararat	3.84	-	30.88	-	43.35	-	41.22	-	20.64	-	12.32	-	17.60	-
Armavir	3.27	-	30.72	-	35.20	-	33.00	-	17.58	-	11.13	-	15.39	-
Gegharkunik	2.77	-	19.27	-	30.63	-	NA	-	NA	-	16.75	-	3.08	-
Lori	2.29	-	12.97	-	13.09	-	5.63	-	2.38	-	2.08	-	3.42	-
Kotayk	1.87	-	20.09	-	17.93	-	NA	-	1.49	-	4.88	-	5.35	-
Shirak	2.60	-	23.64	-	25.46	-	NA	-	NA	-	9.67	-	3.18	-
Syunik	2.06	-	16.85	-	16.93	-	NA	-	5.65	-	5.86	-	3.81	-
Vayots Dzor	2.06	-	17.08	-	15.44	-	17.00	-	4.98	-	4.57	-	7.12	-
Tavush	3.11	-	11.41	-	9.49	-	21.97	-	9.42	-	6.76	-	5.29	-
Total	**2.58**	**-**	**19.43**	**-**	**31.76**	**-**	**35.08**	**-**	**15.21**	**-**	**8.64**	**-**	**6.50**	**-**

Source: The Ministry of Agriculture, RA

Appendix C-9 Number of Beef Cattle by Marzes (2009-2013)

Marzes	2009		2010		2011		2012		2013	
	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)
Yerevan	2,259	0.4	1,691	0.3	2,523	0.4	2,673	0.4	3,750	0.6
Aragatsotn	70,157	12.3	70,781	12.4	75,702	12.6	85,161	12.9	85,263	12.6
Ararat	41,171	7.2	41,204	7.2	41,434	6.9	44,225	6.7	46,376	6.8
Armavir	41,538	7.3	42,103	7.4	47,730	8.0	54,984	8.3	55,796	8.2
Gegharkunik	101,910	17.9	95,880	16.8	98,486	16.4	112,265	17.0	115,619	17.1
Lori	69,040	12.1	69,665	12.2	74,267	12.4	81,540	12.3	81,850	12.1
Kotayk	48,305	8.5	52,055	9.1	54,247	9.1	59,455	9.0	61,464	9.1
Shirak	95,934	16.8	96,717	16.9	99,683	16.6	105,729	16.0	107,097	15.8
Syunik	50,659	8.9	51,201	9.0	52,508	8.8	56,273	8.5	60,548	8.9
Vayots Dzor	15,909	2.8	16,305	2.9	18,527	3.1	22,738	3.4	22,749	3.4
Tavush	33,751	5.9	33,755	5.9	34,136	5.7	35,960	5.4	37,072	5.5
Total	**570,633**	**100.0**	**571,357**	**100.0**	**599,243**	**100.0**	**661,003**	**100.0**	**677,584**	**100.0**

Source: The Ministry of Agriculture, RA

Appendix C-10 Number of Milk Cows by Marzes (2009-2013)

Marzes	2009		2010		2011		2012		2013	
	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)
Yerevan	1,323	0.5	1,124	0.4	1,146	0.4	1,166	0.4	1,271	0.4
Aragatsotn	33,773	12.3	34,074	12.5	36,920	13.0	40,326	13.3	40,350	13.0
Ararat	16,940	6.2	15,676	5.8	16,482	5.8	17,321	5.7	17,721	5.7
Armavir	16,498	6.0	16,518	6.1	18,212	6.4	19,972	6.6	20,143	6.5
Gegharkunik	50,617	18.5	51,871	19.0	52,035	18.4	54,271	17.9	56,735	18.3
Lori	35,138	12.8	33,648	12.3	36,143	12.8	39,127	12.9	39,193	12.7
Kotayk	24,164	8.8	24,614	9.0	26,004	9.2	27,434	9.0	28,152	9.1
Shirak	46,100	16.8	45,540	16.7	45,916	16.2	50,152	16.5	50,567	16.3
Syunik	25,265	9.2	25,313	9.3	25,727	9.1	26,742	8.8	28,281	9.1
Vayots Dzor	7,716	2.8	7,863	2.9	8,326	2.9	9,576	3.2	9,676	3.1
Tavush	16,320	6.0	16,331	6.0	16,438	5.8	17,190	5.7	17,527	5.7
Total	**273,854**	**100.0**	**272,572**	**100.0**	**283,349**	**100.0**	**303,277**	**100.0**	**309,616**	**100.0**

Source: The Ministry of Agriculture, RA

Appendix C-11 Number of Sheep & Goats by Marzes (2009-2013)

Marzes	2009		2010		2011		2012		2013	
	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)
Yerevan	1,510	0.3	2,164	0.4	1,865	0.3	1,984	0.3	6,297	0.9
Aragatsotn	71,387	14.0	73,516	13.8	82,158	13.9	95,914	14.2	96,766	13.5
Ararat	65,874	12.9	66,129	12.4	70,483	11.9	81,369	12.1	92,503	12.9
Armavir	58,858	11.5	61,341	11.5	71,033	12.0	92,485	13.7	91,114	12.7
Gegharkunik	85,242	16.7	90,822	17.1	91,680	15.5	101,388	15.0	102,613	14.3
Lori	28,515	5.6	28,747	5.4	28,746	4.9	32,190	4.8	37,851	5.3
Kotayk	35,192	6.9	35,788	6.7	40,979	6.9	44,247	6.6	46,108	6.4
Shirak	68,366	13.4	69,141	13.0	82,310	13.9	86,484	12.8	90,400	12.6
Syunik	64,964	12.7	73,186	13.7	86,284	14.6	101,559	15.1	114,655	16.0
Vayots Dzor	16,966	3.3	17,107	3.2	19,530	3.3	21,377	3.2	23,097	3.2
Tavush	14,155	2.8	14,574	2.7	15,146	2.6	15,734	2.3	16,170	2.3
Total	**511,029**	**100.0**	**532,515**	**100.0**	**590,214**	**100.0**	**674,731**	**100.0**	**717,574**	**100.0**

Source: The Ministry of Agriculture, RA

Appendix C-12 Number of Pigs by Marzes (2009-2013)

Marzes	2009		2010		2011		2012		2013	
	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)
Yerevan	5,621	5.0	7,298	6.4	5,361	5.0	6,171	4.3	6,478	4.6
Aragatsotn	9,557	8.5	10,519	9.2	9,513	8.8	10,513	7.2	10,521	7.5
Ararat	15,279	13.6	12,473	10.9	12,032	11.1	18,120	12.5	19,434	13.9
Armavir	15,913	14.1	15,562	13.6	12,402	11.5	20,683	14.3	19,999	14.3
Gegharkunik	8,416	7.5	8,541	7.4	7,973	7.4	11,912	8.2	11,527	8.2
Lori	9,525	8.5	8,509	7.4	7,446	6.9	13,701	9.4	12,255	8.8
Kotayk	12,707	11.3	15,109	13.2	14,588	13.5	19,213	13.2	15,305	10.9
Shirak	14,528	12.9	13,517	11.8	15,272	14.1	15,703	10.8	13,810	9.9
Syunik	6,321	5.6	7,613	6.6	7,751	7.2	10,586	7.3	11,686	8.4
Vayots Dzor	1,393	1.2	1,940	1.7	1,404	1.3	1,921	1.3	1,890	1.4
Tavush	13,348	11.9	13,696	11.9	14,346	13.3	16,521	11.4	16,894	12.1
Total	**112,608**	**100.0**	**114,777**	**100.0**	**108,088**	**100.0**	**145,044**	**100.0**	**139,799**	**100.0**

Source: The Ministry of Agriculture, RA

Appendix C-13 Number of Poultry by Marzes (2009-2013)

Marzes	2009		2010		2011		2012		2013	
	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)	(head)	(%)
Yerevan	187149	4.7	212222	6.5	189661	4.9	195088	5.1	156833	4.0
Aragatsotn	362,180	9.2	292,153	9.0	288,113	7.5	324,755	8.4	336,344	8.5
Ararat	306,121	7.8	257,782	7.9	289,612	7.6	326,580	8.5	336,971	8.5
Armavir	871,273	22.1	816,360	25.1	1,113,671	29.0	1,516,965	39.4	1,420,978	36.0
Gegharkunik	356,387	9.0	219,858	6.8	256,565	6.7	317,982	8.2	311,845	7.9
Lori	195,024	4.9	197,828	6.1	182,088	4.7	160,350	4.2	163,706	4.2
Kotayk	1,028,429	26.1	894,633	27.5	1,071,316	27.9	582,409	15.1	620,639	15.7
Shirak	257,158	6.5	217,226	6.7	213,152	5.6	206,439	5.4	188,757	4.8
Syunik	218,772	5.5	110,823	3.4	142,690	3.7	153,454	4.0	297,090	7.5
Vayots Dzor	108,899	2.8	52,059	1.6	82,434	2.2	67,572	1.8	63,110	1.6
Tavush	243,246	6.2	191,585	5.9	194,180	5.1	198,407	5.1	204,922	5.2
Total	**3,947,489**	**100.0**	**3,250,307**	**100.0**	**3,833,821**	**100.0**	**3,854,913**	**100.0**	**3,944,362**	**100.0**

Source: The Ministry of Agriculture, RA

Appendix C-14 Marketed Meat (Live animals) by Marzes (2009-2013)

Marzes	2009		2010		2011		2012		2013	
	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)
Yerevan	0.5	0.4	0.5	0.4	0.6	0.5	0.8	0.6	1.8	1.2
Aragatsotn	14	11.1	14.4	11.6	14.7	11.5	14.7	11.3	15.6	10.6
Ararat	8.5	6.7	8	6.4	8.3	6.5	8.7	6.7	9.8	6.7
Armavir	9.7	7.7	10	8.0	10.3	8.1	11	8.4	15.4	10.5
Gegharkunik	21.7	17.2	21.5	17.3	21.8	17.0	21.8	16.7	23.5	16.0
Lori	14.8	11.7	14.6	11.7	15	11.7	15.1	11.6	16.3	11.1
Kotayk	13.1	10.4	12.1	9.7	12.6	9.9	12.9	9.9	14.7	10.0
Shirak	19.4	15.4	19.8	15.9	20	15.6	20	15.3	21.4	14.6
Syunik	11.6	9.2	11.1	8.9	11.8	9.2	12	9.2	13.9	9.5
Vayots Dzor	5.3	4.2	4.7	3.8	4.8	3.8	5	3.8	5.6	3.8
Tavush	7.6	6.0	7.6	6.1	8	6.3	8.3	6.4	8.8	6.0
Total	**126.2**	**100.0**	**124.3**	**100.0**	**127.9**	**100.0**	**130.3**	**100.0**	**146.8**	**100.0**

Source: The Ministry of Agriculture, RA

Appendix C-15 Marketed Meat (Live animals) by Categories of Meat (2009-2013)

Category		2009		2010		2011		2012		2013	
		('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)
Live animals		126.2	-	124.3	-	127.9	-	130.3	-	146.8	-
Slaughtered		70.7	100.0	69.5	100.0	71.7	100.0	73.9	100.0	83.4	100.0
1	Beef & veal	49.6	70.2	48.0	69.1	48.2	67.2	47.6	64.4	53.6	64.3
2	Pork	7.2	10.2	7.9	11.4	9.4	13.1	9.5	12.9	12.6	15.1
3	Mutton & lamb	8.9	12.6	8.2	11.8	8.4	11.7	8.5	11.5	9.0	10.8
4	Poultry	5.0	7.1	5.4	7.8	5.7	7.9	8.3	11.2	8.2	9.8

Source: The Ministry of Agriculture, RA

Appendix C-16 Milk Production by Marzes (2009-2013)

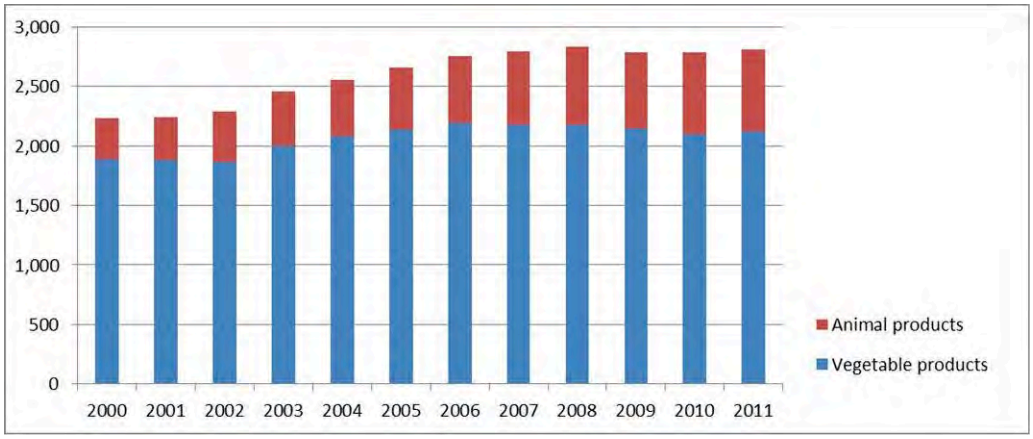
Marzes	2009		2010		2011		2012		2013	
	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)	('000 ton)	(%)
Yerevan	2.0	0.3	2.3	0.4	2.0	0.3	2.2	0.4	2.5	0.4
Aragatsotn	75.9	12.3	74.1	12.3	74.8	12.4	76.5	12.4	79.9	12.2
Ararat	38.0	6.2	38.1	6.3	36.5	6.1	38.2	6.2	40.1	6.1
Armavir	38.0	6.2	36.1	6.0	36.1	6.0	37.4	6.0	40.5	6.2
Gegharkunik	116.4	18.9	112.4	18.7	114.5	19.0	116.3	18.8	120.7	18.4
Lori	80.8	13.1	77.1	12.8	76.2	12.7	77.7	12.6	81.3	12.4
Kotayk	55.9	9.1	51.3	8.5	51.8	8.6	53.5	8.7	57.9	8.8
Shirak	98.6	16.0	99.0	16.5	98.8	16.4	101.5	16.4	107.6	16.4
Syunik	58.4	9.5	55.8	9.3	55.9	9.3	57.2	9.3	62.2	9.5
Vayots Dzor	17.1	2.8	19.9	3.3	20.0	3.3	21.1	3.4	24.8	3.8
Tavush	34.6	5.6	34.8	5.8	34.9	5.8	36.6	5.9	39.5	6.0
Total	**615.7**	**100.0**	**600.9**	**100.0**	**601.5**	**100.0**	**618.2**	**100.0**	**657.0**	**100.0**

Source: The Ministry of Agriculture, RA

Appendix C-17 Egg Production by Marzes (2009-2013)

Marzes	2009		2010		2011		2012		2013	
	(mil. pcs)	(%)	(mil. pcs)	(%)	(mil. pcs)	(%)	(mil. pcs)	(%)	(mil. pcs)	(%)
Yerevan	32.0	5.1	33.5	4.8	27.9	4.4	35.6	5.4	28.7	4.7
Aragatsotn	47.1	7.5	70.4	10.0	59.7	9.4	61.7	9.4	59.4	9.7
Ararat	56.3	8.9	76.7	10.9	55.0	8.7	55.0	8.4	54.7	8.9
Armavir	92.4	14.7	126.3	18.0	135.5	21.4	140.1	21.3	127.7	20.8
Gegharkunik	60.5	9.6	68.3	9.7	56.6	8.9	57.1	8.7	58.2	9.5
Lori	34.4	5.5	39.7	5.7	47.3	7.5	47.3	7.2	43.7	7.1
Kotayk	181.4	28.8	156.4	22.3	125.7	19.8	132.1	20.1	117.3	19.1
Shirak	41.9	6.6	40.3	5.7	39.7	6.3	40.9	6.2	40.1	6.5
Syunik	24.8	3.9	28.2	4.0	26.9	4.2	27.2	4.1	26.3	4.3
Vayots Dzor	15.0	2.4	17.6	2.5	17.5	2.8	18.2	2.8	17.4	2.8
Tavush	44.3	7.0	44.8	6.4	41.8	6.6	42.9	6.5	41.7	6.8
Total	**630.1**	**100.0**	**702.2**	**100.0**	**633.6**	**100.0**	**658.1**	**100.0**	**615.2**	**100.0**

Source: The Ministry of Agriculture, RA



Source：The JICA Study Team (based on FAOSTAT)

Appendix C-18 Per-capita Calorie Intake (Kcal/day)

Appendix C-19 Per-capita Food Supply by Food Groups (kg/year)

Food Group	2000	2007	2008	2009	2010	2011
Cereals	161.9	154.8	150.2	140.5	139.7	144.7
Potatoes	63.8	51.2	50.4	57.3	48.3	44.2
Vegetables	120.6	328.8	325.2	335.2	271.0	311.4
Fruits	48.1	91.3	112.5	120.3	65.5	79.6
Meat	20.8	37.1	48.4	40.4	40.8	42.2
Milk	93.6	172.9	161.2	177.9	189	189.9
Egg	4.9	9.0	10.1	10.8	12.5	11.5
Vegetable oils	3.6	7.4	7.0	7.1	7.4	7.8
Sugar & Sweeteners	24.7	31.8	33.6	33.7	41.2	37.8
Fish, Seafood	1.0	2.3	3.4	3.0	2.4	3.0

Source: FAOSTAT

Appendix C-20 Import of Agricultural Products（2008-2012） (Million US$)

Category (Import)	2008	2009	2010	2011	2012
Total Import	**4,426,129.3**	**3,321,133.9**	**3,748,953.5**	**4,145,332.0**	**4,261,232.7**
(CIS)	**(1,262,771.5)**	**(1,041,770.3)**	**(1,142,160.2)**	**(1,208,823.7)**	**(1,334,524.7)**
(Non-CIS)	**(3,163,357.9)**	**(2,279,363.6)**	**(2,606,793.3)**	**(2,936,508.2)**	**(2,926,708.1)**
Cereals	110,467.4	108,919.9	105,419.9	111,856.4	151,836.0
(CIS)	(98,892.2)	(102,519.8)	(94,334.7)	(98,596.7)	(144,017.3)
(Non-CIS)	(11,575.2)	(6,400.0)	(11,085.2)	(13,259.7)	(7,818.7)
Oil seeds	10,482.0	7,087.8	7,803.4	9,201.1	7,632.0
(CIS)	(2,664.5)	(4,793.6)	(4,824.5)	(4,776.0)	(4,553.7)
(Non-CIS)	(7,817.5)	(2,294.2)	(2,978.9)	(4,425.2)	(3,078.2)
Vegetables & tubers	13,587.2	8,641.7	13,399.7	19,045.6	14,157.8
(CIS)	(1,533.2)	(1,734.2)	(1,117.4)	(1,547.2)	(2,269.8)
(Non-CIS)	(12,054.0)	(6,907.5)	(12,282.3)	(17,498.4)	(11,888.0)
Fruits & nuts	40,637.2	33,711.6	43,596.6	47,282.3	39,094.5
(CIS)	(366.5)	(517.9)	(227.3)	(259.2)	(101.9)
(Non-CIS)	(40,270.7)	(33,193.8)	(43,369.3)	(47,023.1)	(38,992.6)
Live animals	5,421.9	3,757.9	2,746.0	3,424.2	4,094.3
(CIS)	(290.6)	(38.8)	(105.9)	(232.2)	(15.4)
(Non-CIS)	(5,131.4)	(3,719.1)	(2,640.1)	(3,191.9)	(4,078.9)
Fishes	3,626.4	4,871.8	3,067.5	3,562.2	4,365.7
(CIS)	(428.6)	(321.3)	(293.2)	(367.7)	(237.2)
(Non-CIS)	(3,197.8)	(4,550.5)	(2,774.3)	(3,194.6)	(4,128.5)
Products of milling	17,359.6	7,773.4	8,590.8	15,459.5	7,331.2
(CIS)	(7,838.5)	(6,108.5)	(6,051.3)	(12,347.8)	(2,121.7)
(Non-CIS)	(9,521.1)	(1,664.9)	(2,539.5)	(3,111.7)	(5,209.4)
Products from flour & cereals or pastry products	25,108.8	18,165.4	20,274.3	22,730.1	26,098.4
(CIS)	(15,707.7)	(11,815.6)	(12,760.8)	(13,676.7)	(15,800.4)
(Non-CIS)	(9,401.1)	(6,349.8)	(7,513.5)	(9,053.4)	(10,298.0)
Products from vege. & Fruits	22,704.3	16,352.6	15,924.0	21,259.6	17,714.3
(CIS)	(5,010.7)	(2,685.9)	(2,907.3)	(2,826.3)	(2,373.2)
(Non-CIS)	(17,693.6)	(13,666.7)	(13,016.7)	(18,433.3)	(15,341.1)
Alcoholic & nonalcoholic drinks	62,895.0	42,076.8	52,568.5	47,121.8	52,723.8
(CIS)	(44,777.3)	(29,479.7)	(34,888.2)	(28,770.3)	(27,818.2)
(Non-CIS)	(18,117.7)	(12,597.1)	(17,680.3)	(18,351.5)	(24,905.6)
Meats & offal	89,156.4	69,632.1	69,051.3	88,465.6	88,696.8
(CIS)	(297.0)	(547.5)	(1,526.6)	(2,364.3)	(1,174.9)
(Non-CIS)	(88,859.3)	(69,084.6)	(67,524.7)	(86,101.3)	(87,521.8)
Milk/Daily products/Eggs/ Honey	27,193.6	18,546.9	25,565.5	35,857.7	37,228.5
(CIS)	(12,368.9)	(12,373.5)	(10,870.2)	(16,099.4)	(10,227.1)
(Non-CIS)	(14,824.6)	(6,173.3)	(14,695.3)	(19,758.3)	(27,001.4)
Fats & oil (animal/vege.)	52,825.6	51,777.2	49,217.1	57,947.2	59,570.9
(CIS)	(32,096.1)	(29,482.7)	(33,319.4)	(41,418.5)	(46,643.0)
(Non-CIS)	(20,729.5)	(22,294.5)	(15,897.7)	(16,528.6)	(12,927.9)
Sugar & confectionery	42,277.2	29,899.8	42,955.4	65,899.1	62,547.8
(CIS)	(5,352.6)	(4,848.1)	(5,658.6)	(6,336.1)	(6,033.6)
(Non-CIS)	(36,924.7)	(25,051.8)	(37,296.8)	(59,563.0)	(56,514.2)

Source：armstat (http://www.armstat.am/en/?nid=45)

Appendix C-21 Export of Agricultural Products（2008-2012） (Million US$)

Category (Export)	2008	2009	2010	2011	2012
Total Export	**1,057,161.4**	**710,157.5**	**1,041,056.6**	**1,334,338.8**	**1,380,199.2**
(CIS)	**(249,215.5)**	**(138,327.5)**	**(198,773.9)**	**(268,062.3)**	**(336,604.2)**
(Non-CIS)	**(807,945.9)**	**(571,830.0)**	**(842,282.7)**	**(166,276.5)**	**(1,043,595.0)**
Cereals	11.9	0.1	7.0	4.7	0.1
(CIS)	(3.0)	(0.0)	(0.0)	(4.4)	(0.0)
(Non-CIS)	(8.9)	(0.1)	(7.0)	(0.3)	(0.1)
Oil seeds	36.9	45.4	127.4	101.0	112.4
(CIS)	(29.4)	(18.4)	(42.2)	(71.6)	(73.4)
(Non-CIS)	(7.5)	(27.0)	(85.2)	(29.4)	(38.9)
Vegetables & tubers	1,773.5	1,603.3	2,594.6	1,663.1	2,167.2
(CIS)	(205.1)	(158.4)	(1,619.7)	(935.0)	(841.0)
(Non-CIS)	(1,568.3)	(1,444.9)	(974.9)	(728.1)	(1,326.3)
Fruits & nuts	4,972.6	8,261.2	6,887.2	15,476.5	24,476.9
(CIS)	(3,714.9)	(6,954.1)	(6,644.3)	(14,227.5)	(23,384.2)
(Non-CIS)	(1,257.7)	(1,307.1)	(242.9)	(1,249.0)	(1,092.7)
Live animals	1,484.6	9,203.9	13,756.6	12,210.1	8,770.1
(CIS)	(46.6)	(2.1)	(5.5)	(1.2)	(32.4)
(Non-CIS)	(1,438.1)	(9,201.8)	(13,751.1)	(12,208.9)	(8,737.7)
Fishes	4,994.8	3,221.5	7,707.1	15,467.8	21,340.6
(CIS)	(1,405.5)	(677.0)	(5,602.7)	(13,059.9)	(19,374.8)
(Non-CIS)	(3,589.3)	(2,544.5)	(2,104.4)	(2,587.9)	(1,965.8)
Products of milling	25.0	72.8	55.2	66.1	134.0
(CIS)	(4.4)	(30.7)	(16.8)	(36.8)	(27.2)
(Non-CIS)	(20.6)	(42.0)	(38.4)	(29.3)	(106.8)
Products from flour & cereals or pastry products	465.9	381.5	316.6	470.7	879.9
(CIS)	(0.3)	(18.8)	(4.7)	(35.0)	(97.1)
(Non-CIS)	(465.6)	(362.7)	(311.9)	(435.8)	(842.8)
Products from vege. & fruits	10,782.8	7,744.2	8,675.8	12,874.4	17,177.4
(CIS)	(8,650.8)	(4,910.4)	(5,027.9)	(8,917.2)	(13,520.3)
(Non-CIS)	(2,132.0)	(2,833.9)	(3,647.9)	(3,957.2)	(3,657.1)
Alcoholic & nonalcoholic drinks	145,379.5	80,114.2	109,071.2	147,130.6	186,538.4
(CIS)	(136,426.6)	(72,278.0)	(98,575.1)	(121,032.6)	(168,827.4)
(Non-CIS)	(8,952.9)	(7,836.2)	(10,496.1)	(26,098.0)	(17,711.0)
Meats & offal	757.2	1,164.4	58.8	23.8	94.3
(CIS)	(0.0)	(8.3)	(0.0)	(0.0)	(10.9)
(Non-CIS)	(757.2)	(1,156.0)	(58.8)	(23.8)	(83.4)
Milk/Daily products/Eggs/ Honey	2,093.2	1,449.9	1,985.1	2,112.4	2,800.0
(CIS)	(812.5)	(735.4)	(1,182.2)	(1,503.2)	(2,533.8)
(Non-CIS)	(1,280.7)	(714.5)	(802.9)	(609.2)	(266.2)
Fats & oil (animal/vege.)	47.9	2.9	29.1	25.3	55.8
(CIS)	(0.0)	(0.0)	(0.1)	(0.3)	(0.0)
(Non-CIS)	(47.9)	(2.9)	(29.0)	(25.0)	(55.8)
Sugar & confectionery	66.3	95.5	1,562.0	2,912.7	844.3
(CIS)	(17.5)	(0.1)	(0.0)	(13.6)	(9.0)
(Non-CIS)	(48.8)	(95.4)	(1,562.0)	(2,899.1)	(835.3)

Source：armstat (http://www.armstat.am/en/?nid=45)

Appendix C-22 Distribution Plan of Seeds by the Government Programs in 2013

Marz	Amount of Seeds (ton)				
	Wheat	Barley	Maize	Alfalfa	Melilot
Yerevan	0.0	0.0	0.0	0.0	0.0
Aragatsotn	200.0	100.0	1.0	5.0	15.0
Ararat	240.0	0.0	0.5	1.47	0.0
Armavir	118.0	7.0	0.0	1.63	3.0
Gegharkunik	355.0	0.0	0.0	6.0	350
Lori	250.0	66.0	4.0	3.0	4.0
Kotayk	0.0	85.0	0.0	0.0	2.0
Shirak	1,270.0	107.0	3.025	10.35	131.0
Syunik	650.0	400.0	0.75	3.0	20.0
Vayots Dzor	70.0	40.0	0.225	0.15	1.0
Tavush	300.0	45.0	1.5	6.40	4.0
Total	**3,453.0**	**850.0**	**11.0**	**37.0**	**530.0**

Source： The RA Government Decision N905, August 22, 2013(Wheat)
The RA Government Decision N165, February 21, 2013(Barley, Maize, Alfalfa, Melilot)

Appendix C-23 Distribution Plan of Fertilizers by the Government Programs in 2014

Marz	Amount of Fertilizers (ton)		
	Ammonium Nitrate	Double Superphosphate	Potassium Chloride
Yerevan	0.00	0.00	0.0
Aragatsotn	3,500.00	85.00	142.00
Ararat	3,888.35	457.15	326.20
Armavir	7,000.00	300.00	200.00
Gegharkunik	5,989.50	329.00	299.40
Lori	2,000.00	36.05	29.80
Kotayk	1,548.00	38.50	25.50
Shirak	5,630.90	595.40	464.90
Syunik	2,200.00	160.00	20.00
Vayots Dzor	470.00	4.00	4.00
Tavush	400.00	30.00	30.00
Nagorno Karabakh	1,000.00	500.00	0.00
Total	**33,626.75**	**2,535.10**	**1,541.80**

Source： The RA Government Decision N150, February 6, 2014

Appendix C-24 Number of Tractors & Combine Harvesters in Operation and Farmland Area in 2013

Marz	Annual Crop Cultivated Area (ha)	Number of Tractor in Operate	Area/ Tractor (ha)	Cereal Area (ha)	Number of C. Harvester in Operate	Area/ C. Harvester (ha)
Yerevan	570	620	0.9	112	9	12.4
Aragatsotn	28,773	1,022	28.2	24,424	120	203.5
Ararat	15,366	1,018	15.1	5,526	31	178.3
Armavir	21,253	1,480	14.4	6,041	45	134.2
Gegharkunik	61,032	2,163	28.2	41,753	246	169.7
Lori	18,410	1,350	13.6	11,245	87	129.3
Kotayk	14,629	628	23.3	12,017	61	197.0
Shirak	50,173	1,203	41.7	42,346	218	194.2
Syunik	27,017	818	33.0	23,181	121	191.6
Vayots Dzor	3,337	555	6.0	2,495	24	104.0
Tavush	12,472	768	16.2	9,097	43	211.6
Total	253,032	11,625	21.8	178,237	1,005	177.4

Source：The JICA Study Team (based on information from the Ministry of Agriculture, RA)

Appendix C-25 Price of Agricultural Machinery Service (as of Aug. of 2014)

Machinery Service	Price (AMD/ha)
Plowing & Leveling & Seeding	60,000 – 70,000
Plowing only	30,000
Leveling & Seeding	35,000
Harvesting (wheat & barley)	30,000
Harvesting (Alfalfa)	20,000 – 30,000
Hay-cube baling	150/cube

Source：The JICA Study Team (based on collected information)

Appendix C-26 Leading Agribusiness Companies in Armenia

Name	Place	Major Products
Yerevan Ararat Brandy-Wine-Vodka Factory	Yerevan	Brandy, Wine
Yerevan Brandy Factory	Yerevan	Brandy
Vadi Alco	Vadi	Wine, Vodka, Brandy
Getnatun	Yeghegnadzor	Wine
Gyumri-Garejour	Gyumri	Beer
Aleksandrapol	Gyumri	Beer
Yerevan Brewery	Yerevan	Beer
Kotayk Brewery	Kotayk	Beer
Euro Term	Yerevan	Natural juice, Sterilized milk
Lisakert poultry factory	Kotayk	Broiler, Eggs
Arpa Alco	Vayots Dzor	Wine
Bari Samaratsi	Yerevan	Meet products (sausages, hams, etc.)
Sis natural	Yerevan	Juice, Jams, Marinades, Canned vegetables
Atenk	Yerevan	Meet products (sausages, hams, etc.)
Dustr Marianna	Yerevan	Dairy products
Meghri Cannery	Syunik	Canned fruits
Alishan	Ararat	Juice, Nectars, Fruits preserves, Dry fruits
Tamara Fruits	Aragatsotn	Deep freezing fruits & vegetables, Juice, Jams
Agrospasarkum	Yerevan	Dairy products
Artfood	Yerevan	Canned foods
Yerevan Champagne Wines Factory	Yerevan	Wine, Sparkling wine
VAN 777	Ararat	Wine
Elola	Syuniq	Dairy products
Dustr Melania	Lori	Milk, Cheese
HAM	Lori	Herbal teas

Source：Agricultural and Food Processing in Armenia, Samvel Avetisyan, USDA & CARD, 2010

Appendix C-27 Volumes of Vegetables, Fruits and Grape Purchased by Processing Enterprises (1998-2009)

(ton)

Year	Vegetables	Fruits	Grapes
1998	4,200	9,077	41,938
1999	39,226	12,198	50,300
2000	39,440	21,003	50,714
2001	26,142	10,248	37,032
2002	52,065	5,900	47,026
2003	96,570	4,362	50,947
2004	35,806	4,394	79,539
2005	42,925	20,715	95,592
2006	67,563	12,789	106,055
2007	57,111	14,844	144,389
2008	38,999	19,406	137,356
2009	32,309	11,255	127,740

Source：Agricultural and Food Processing in Armenia, Samvel Avetisyan, USDA & CARD, 2010

Appendix C-28 Processing Volumes of Vegetables, Fruits and Grape Products in Armenia

Products	Unit	Year							
		Ave. 1986-90	2001	2002	2003	2004	2005	2006	2007
Preserved Vegetables	X 1000 cans	143,330	22,705	45,370	92,872	38,839	43,120	66,260	59,000
	(%)	(100.00)	(15.84)	(31.65)	(64.80)	(27.10)	(30.08)	(46.16)	(41.16)
Preserved Fruits	X 1000 cans	275,826	17,160	8,114	7,348	8,311	48,800	32,700	37,100
	(%)	(100.00)	(6.22)	(2.94)	(2.66)	(3.00)	(17.69)	(11.86)	(13.45)
Grape wine	x 10000 liters	4,636	639	654	204	232	242.5	383	365
	(%)	(100.00)	(13.78)	(14.11)	(4.40)	(5.00)	(5.23)	(8.26)	(7.87)
Sparkling wine	x 10000 liters	229	58	62	67	57	52	54.3	57.9
	(%)	(100.00)	(25.33)	(27.07)	(29.26)	(24.89)	(22.71)	(23.71)	(25.28)
Brandy	x 10000 liters	1,119	503	606	722	710	879	906	1,408
	(%)	(100.00)	(44.95)	(54.16)	(64.52)	(63.45)	(78.55)	(80.97)	(125.83)

Source：Agricultural and Food Processing in Armenia, Samvel Avetisyan, USDA & CARD, 2010

Appendix C-29 Farm-gate Price of Major Farm Products (Last 1 year)

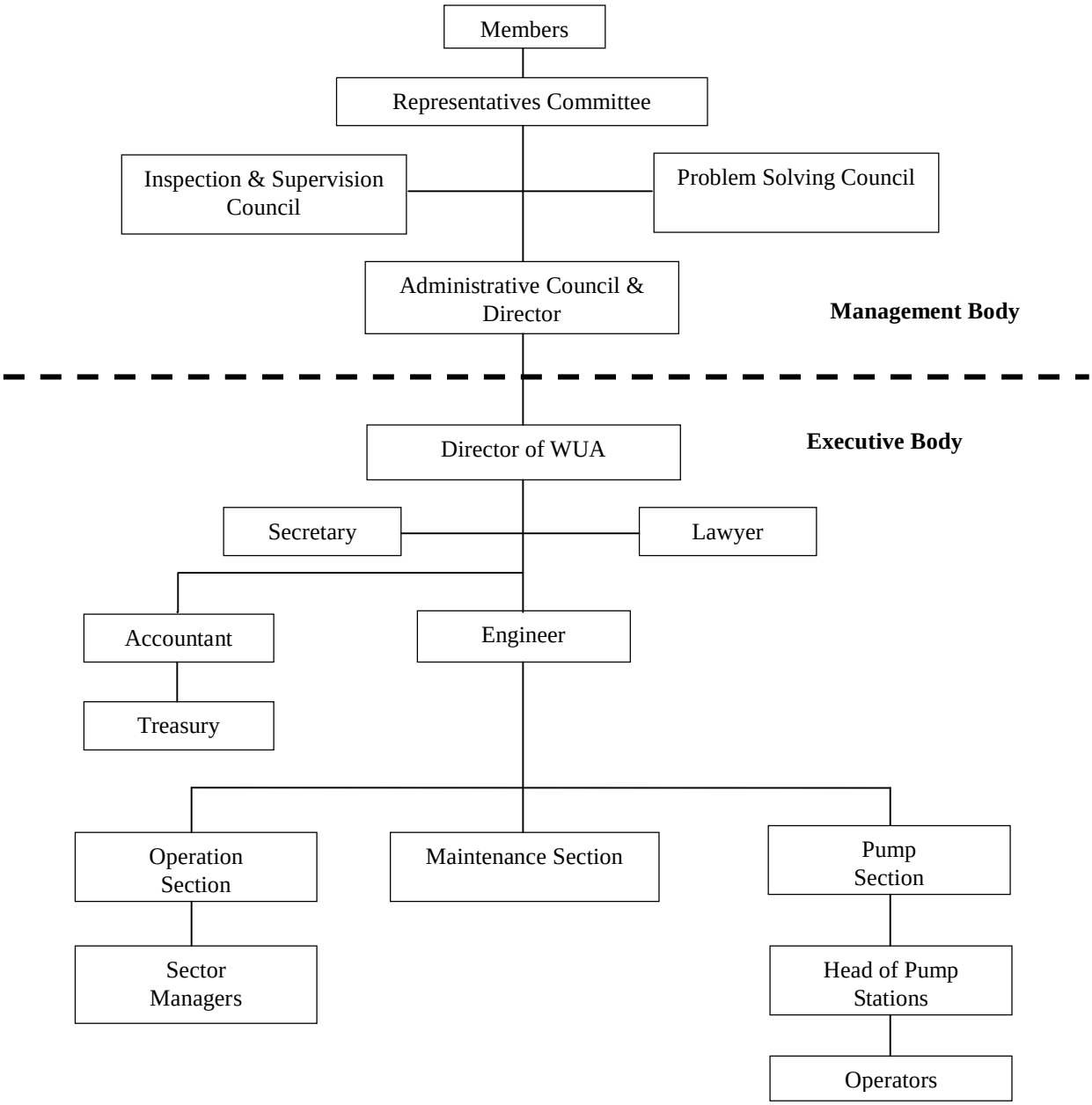
No.	Crop/Product	unit	Price (Armenia Dram)		
			Average/Common	Maximum	Minimum
1	Wheat	kg	150	170 - 190	125 - 130
			-	month: March	month: July - Aug
2	Barley	kg	180	190	130
			-	month: March	month: July - Aug
3	Maize	kg	150	200	150
			-	month: Dec - Feb	month: Sep end
4	Alfalfa (dry)	cube (18-20kg)	800 - 1,000	1,500	800
			-	month: Feb - Mar	month: June
5	Potato	kg	100	200 - 250	80
			-	month: Jan	month: June
6	Cabbage	kg	100	200	30
			-	month: May	month: Aug
7	Cucumber	kg	140 - 150	800 - 1,000	50 - 100
			-	month: Mar	month: Aug
8	Tomato	kg	80	600	40
			-	month: Jan - Feb	month: Aug - Sep
9	Pepper	kg	150	1,500	80
			-	month: Jan - Feb	month: Aug
10	Egg plant	kg	100	1,100 - 1,200	30
			-	month: Feb - Mar	month: Aug
11	Onion	kg	150	300	130
			-	month: Feb - Apr	month: Aug - Sep
12	Water melon	kg	90 - 100	500 - 600	80 - 90
			-	month: Jan - Mar	month: July - Aug
13	Strawberry	kg	500	5,000 - 6,000	500
			-	month: Feb - Apr	month: June
14	Apple	kg	200	500	150
			-	month: Dec - Jan	month: Oct end
15	Grape	kg	145 - 150	800 - 1,000	145 - 150
			(Factory)	month: Jan - Feb	month: Sep (Factory)
16	Apricot	kg	200	500	40 - 50
			-	month: May	month: June
17	Milk	lit.	200 - 250	-	170
			-	-	(Factory)
18	Beef meat (self-slaughtering)	kg	2,100 - 2,200	2,500	-
			-	New year	-
19	Pork meat (self-slaughtering)	kg	2,200 - 2,500	3,000 - 3,400	-
			-	month: Aug	-
20	Egg (Chicken)	kg	70	100	60
			-	New year	-

Source：The JICA Study Team (based on field surveys in August 2014）& the Ministry of Agriculture, RA

Appendix C-30 Outline of WUAs in Armenia

No.	WUA Name	Marz	Number of water users	Irrigated farmland (ha)		% of irrigated farmland	Ave. irrigated land per user (ha)	Number of staff (full-time & part-time)
				Cadastre	Actual			
1	Azat	Ararat	15,558	7,142	4,233	59.3	0.27	177
2	Aparan-Aragats	Aragatsotn	1,470	3,025	510	16.9	0.35	56
3	Aknalich	Armavir	4,737	5,552	2,625	47.3	0.55	56
4	Ararat	Ararat	5,800	8,800	5,500	62.5	0.95	223
5	Araks	Armavir	6,036	7,037	6,217	88.3	1.03	157
6	Artashat	Ararat	9,673	5,639	5,415	96.0	0.56	321
7	Ashtarak	Aragatsotn	5,368	4,300	2,450	57.0	0.46	71
8	Amberd	Aragatsotn	1,472	1,707	350	20.5	0.24	22
9	Utiq	Tavush	3,500	5,500	1,566	28.5	0.45	39
10	Getik	Lori	2,685	3,381	350	10.4	0.13	99
11	Garni-Geghard	Kotayk	1,055	1,853	1,000	54.0	0.95	60
12	Gavar	Gergharkunik	2,893	1,812	452	24.9	0.16	60
13	Yerevan	Yerevan	7,200	3,350	2,330	69.6	0.32	134
14	Yeghegnadzor	Vayotsdzor	5,874	4,299	2,220	51.6	0.38	104
15	Yeghvard	Kotayk	5,360	4,561	2,835	62.2	0.53	107
16	Talin	Aragatsotn	2,727	8,625	4,838	56.1	1.77	247
17	Ijevan	Tavush	500	1,247	550	44.1	1.10	24
18	Loru-Jrantsq	Lori	630	6,999	589	8.4	0.93	142
19	Khoy	Armavir	4,581	5,241	4,972	94.9	1.09	220
20	Kotayk	Kotayk	7,500	5,602	3,103	55.4	0.41	24
21	Hrazdan-Djur	Kotayk	3,500	2,929	450	15.4	0.13	42
22	Kapan	Syunik	650	250	111	44.4	0.17	10
23	Merdzapnia	Armavir	11,200	8,402	6,103	72.6	0.54	340
24	Mekhri	Syunik	1,040	759	509	67.1	0.49	90
25	Masis	Ararat	8,330	4,272	2,628	61.5	0.32	71
26	Martuni	Gergharkunik	8,200	6,200	1,600	25.8	0.20	138
27	Musaler	Armavir	5,569	3,174	2,125	67.0	0.38	75
28	Sisian	Syunik	2,744	4,163	479	11.5	0.17	60
29	Nairi	Kotayk	4,047	2,413	1,399	58.0	0.35	90
30	Noyemberyan	Tavush	1,315	7,779	1,492	19.2	1.13	44
31	Shenik	Armavir	818	9,400	4,156	44.2	5.08	115
32	Shamiram	Aragatsotn	2,316	5,760	3,710	64.4	1.60	103
33	Shirak	Shirak	6,023	19,610	4,187	21.4	0.70	257
34	Vorotan	Syunik	2,100	4,426	587	13.3	0.28	61
35	Jrvezh-Dzoraghpiur	Kotayk	3,820	1,348	1,046	77.6	0.27	56
36	Sev Djue-Akhtamar	Armavir	1,351	3,000	2,140	71.3	1.58	84
37	Vadi	Ararat	7,534	6,797	4,633	68.2	0.61	481
38	Vardenia	Gergharkunik	3,200	4,788	1,560	32.6	0.49	42
39	Vagharshapat	Armavir	5,025	4,758	2,950	62.0	0.59	135
40	Vaik	Vayotsdzor	1,657	1,387	786	56.7	0.47	54
41	Parpi	Aragatsotn	5,300	3,460	2,005	57.9	0.38	58
42	Quasakh	Aragatsotn	2,220	3,025	2,000	66.1	0.90	50
43	Qarakert		2,650	4,971	2,951	59.4	1.11	140
44	Armavir	Armavir	6,658	7,051	6,032	85.5	0.91	188
	Total		191,886	215,794	107,744	49.9	0.56	5,127

Source: Millennium Challenge Account-Armenia Program (http://www.mca.am/en/mca_armenia/issa/wua)



Source: WUA offices

Appendix C-31 WUA Organization Chart

Appendix C-32 State Agricultural Collages under the Ministry of Agriculture

Collage Name	Place
S. Lukashin State Agricultural Collage	Armavir Marz
Gavar Academian Tamamshev State Agricultural Collage	Gegharqunik Marz
Goris Agricultural Collage	Syuniq Marz
Masis State Agricultural Collage	Ararat Marz
Nor Geghi G. Aghajanyan State Agricultural Collage	Kotayk Marz
Stepanavan Prof. Qalantar State Agricultural Collage	Lori Marz
Spitak State Agricultural Collage	Lori Marz
Vanadzor State Agricultural Collage	Lori Marz
Gymri State Agricultural Collage	Shirak Marz
Yerevan State Agricultural Collage	Yerevan

Source：Agricultural and Food Processing in Armenia, Samvel Avetisyan, USDA & CARD, 2010

Appendix C-33 Agricultural Consultancy Services provided by ASMC/ASRC in 2013

Activity	Times/Numbers
Workshops	1,119
Field trainings	872
Technical consultancy events	22,049
Demonstration experimental activities	173
Radio and TV programs	96
Number of topics published in leaflets/brochures	466
(Printing quantity)	(115,270)
Edit materials	158
(Printing quantity)	(209,100)

Source：The Ministry of Agriculture, RA

Appendix C-34 Agricultural Loans provided by the 3 Private Banks (2000-2014)

Year	Loan Amount (Billion AMD)
2000	10.4
2001	9.4
2002	7.8
2003	8.2
2004	8.6
2005	11.3
2006	14.2
2007	22.4
2008	36.5
2009	44.2
2010	52.6
2011	73.4
2012	91.9
2013	103.2
2014 (up to June)	115.9

Source：The Ministry of Agriculture, RA

Appendix-D　Supporting Information of Irrigation

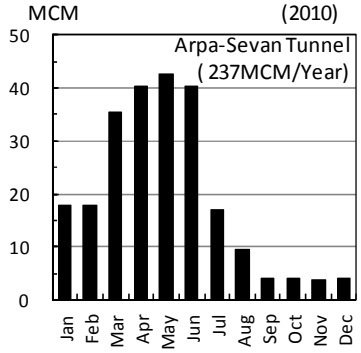
(1) Arpa-Sevan Tunnel and Lake Sevan (Appendix D-1)

Average monthly discharges of Tsovinar observation station of Arpa-Sevan tunnel (m3/sec.)

Water discharges, m3/sec.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	6.72	7.40	13.20	15.60	15.90	15.50	6.30	3.55	1.59	1.56	1.52	1.54
2011	1.70	1.78	1.79	1.70	1.61	1.72	2.50	2.41	1.44	1.26	1.19	1.05
2012	1.02	0.97	1.33	1.54	9.61	7.58	2.20	1.73	1.04	0.76	0.71	0.92

Month (2010)	Discharge (MCM)	Month (2010)	Discharge (MCM)
Jan	18.0	Jul	16.9
Feb	17.9	Aug	9.5
Mar	35.4	Sep	4.1
Apr	40.4	Oct	4.2
May	42.6	Nov	3.9
Jun	40.2	Dec	4.1
		Total	237.2

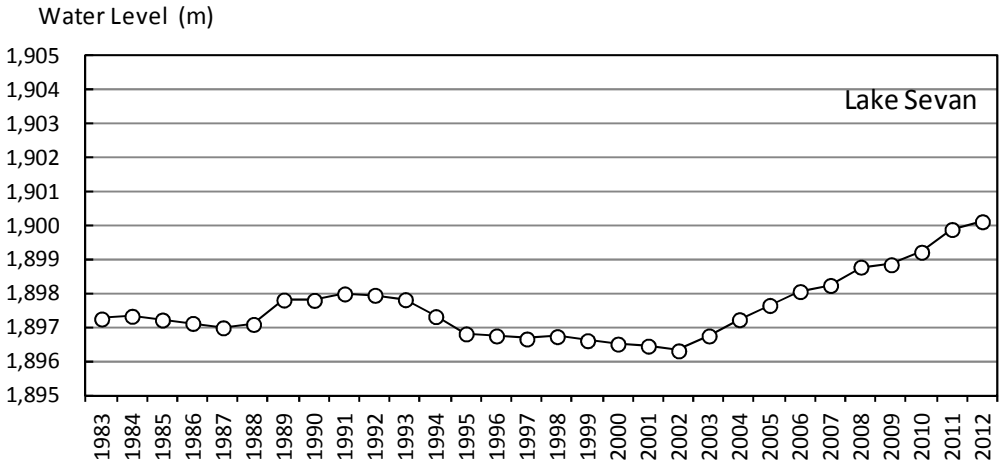


The level and volume of the water of Lake Sevan for 1983-2012 as of January the 1st of each year

Year	Level (m)	Volume (km^3)
1983	1,897.26	34.09
1984	1,897.34	34.19
1985	1,897.23	34.05
1986	1,897.13	33.93
1987	1,897.00	33.76
1988	1,897.10	33.89
1989	1,897.82	34.79
1990	1,897.81	34.77
1991	1,898.00	35.01
1992	1,897.96	34.96

Year	Level (m)	Volume (km^3)
1993	1,897.83	34.80
1994	1,897.33	34.17
1995	1,896.82	33.54
1996	1,896.76	33.47
1997	1,896.67	33.35
1998	1,896.74	33.44
1999	1,896.62	33.29
2000	1,896.52	33.17
2001	1,896.46	33.09
2002	1,896.32	32.92

Year	Level (m)	Volume (km^3)
2003	1,896.76	33.47
2004	1,897.24	34.06
2005	1,897.66	34.59
2006	1,898.07	35.10
2007	1,898.25	35.33
2008	1,898.79	36.01
2009	1,898.86	36.09
2010	1,899.23	36.56
2011	1,899.90	37.41
2012	1,900.13	37.71



Water Level of Sevan Lake(1983-2012)

(2) Meteorological Data (Appendix D-2)

Hrazdan (Latitude 40° 36′, Longitude 44° 46′, height 1765m.)

Monthly average temperature of air (ºC)

	January	February	March	April	May	June	July	August	September	October	November	December
1983	-11.3	-8.3	-2.0	5.9	10.8	13.5	18.1	16.8	12.4	6.6	3.3	-3.4
1984	-4.6	-6.3	1.2	5.5	8.4	13.8	19.0	16.2	14.4	6.7	2.0	-7.9
1985	-5.8	-6.7	-6.4	7.0	11.9	15.3	15.7	17.5	14.1	6.5	3.5	-5.6
1986	-6.5	-3.5	-2.0	7.3	8.6	13.0	18.3	18.2	15.9	7.6	0.3	-5.2
1987	-2.8	-2.4	-3.0	3.5	11.9	15.8	17.7	16.8	12.2	4.3	0.2	-3.4
1988	-7.4	-5.5	-0.7	5.6	9.2	13.5	16.8	15.4	12.2	7.6	0.0	-2.8
1989	-10.3	-8.4	2.4	9.2	11.1	15.1	19.2	18.7	13.7	7.2	1.4	-3.2
1990	-8.8	-5.8	0.0	4.5	10.1	14.8	18.2	16.6	14.5	7.6	3.0	-2.6
1991	-6.9	-7.8	-0.2	7.3	9.4	14.6	17.7	18.3	14.3	9.2	1.4	-5.7
1992	-10.5	-8.5	-4.7	4.1	8.5	13.0	16.6	15.8	12.1	8.0	0.4	-5.1
1993	-8.9	-7.7	-3.3	4.1	9.5	13.9	17.2	16.3	13.2	6.8	-3.3	-4.8
1994	-5.5	-6.8	-0.5	7.6	10.2	13.6	16.3	16.8	14.0	8.9	1.9	-8.4
1998	-	-	-	-	11.3	17.0	18.2	18.6	13.5	9.3	4.8	-0.1
1999	-4.4	-	-	-	-	14.5	17.1	19.2	13.0	7.9	0.8	-2.5
2000	-6.9	-	-	-	-	16.0	23.8	19.0	14.2	7.1	0.9	-3.5
2001	-6.7	-3.0	3.8	7.9	9.9	15.6	18.1	18.8	15.5	8.1	0.3	-2.9
2002	-8.5	-3.0	1.4	4.1	8.9	14.2	17.7	17.5	15.4	9.4	3.0	-8.5
2003	-4.8	-5.1	-3.1	4.2	11.3	13.5	17.2	17.7	13.3	9.8	0.6	-4.2
2004	-6.0	-4.3	1.5	3.9	9.7	14.2	16.1	18.3	13.3	7.9	1.0	-8.8
2005	-8.4	-7.7	-1.1	6.1	10.5	13.7	18.6	18.3	13.6	7.4	1.8	-2.0
2006	-8.3	-4.8	0.9	6.9	11.5	18.0	17.1	20.8	14.0	9.1	0.7	-6.8
2007	-9.5	-6.1	-1.2	2.5	12.2	14.8	16.9	17.5	15.4	9.2	0.6	-5.5
2008	-11.8	-8.5	4.0	9.2	9.2	13.6	17.6	18.5	14.2	8.1	1.8	-5.2
2009	-7.7	-1.8	-0.2	3.4	10.4	14.3	17.1	14.9	11.5	9.0	2.2	-0.8
2010	-2.9	-0.9	3.2	5.5	10.3	16.8	19.5	18.5	16.2	9.0	2.6	-0.2
2011	-6.2	-6.3	-1.3	5.4	10.4	15.4	19.3	17.4	13.5	6.6	-3.5	-7.1
2012	-5.9	-8.7	-4.8	7.7	11.8	15.9	17.6	19.2	14.8	9.4	3.4	-4.4

Monthly average relative humidity of air (%)

	January	February	March	April	May	June	July	August	September	October	November	December
1983	75	78	75	65	72	73	68	68	66	66	82	76
1984	74	74	78	72	70	67	63	65	63	66	80	80
1985	84	78	75	68	68	68	71	59	56	64	73	83
1986	82	80	72	73	75	74	69	65	62	77	84	82
1987	83	83	76	70	62	62	66	65	63	73	70	79
1988	81	80	73	70	71	73	73	74	71	76	71	75
1989	70	71	67	59	63	68	68	65	64	77	80	74
1990	70	74	63	74	66	65	68	69	61	69	74	76
1991	76	73	71	65	65	70	64	67	61	69	79	80
1992	74	-	70	62	-	-	-	-	-	-	-	-
1998	-	-	-	-	84	81	78	65	68	64	78	86
1999	-	-	-	-	-	75	-	68	75	74	80	83
2000	84	-	-	-	-	66	-	60	77	79	83	90
2001	87	89	87	85	82	73	74	76	76	83	79	88
2002	84	85	85	82	75	73	70	70	72	77	81	84
2003	87	87	87	83	70	74	75	73	72	77	85	82
2004	83	83	80	80	77	75	73	72	68	74	81	-
2005	78	78	77	78	83	84	80	79	79	82	77	79
2006	76	77	76	83	76	70	78	71	79	85	73	71
2007	79	74	76	82	79	83	84	81	81	85	81	74
2008	74	72	70	67	77	77	77	70	75	80	80	85
2009	82	78	72	70	68	73	74	77	80	75	82	85
2010	84	84	73	79	77	70	66	61	66	81	68	70
2011	81	78	71	77	76	74	70	72	73	73	80	79
2012	77	77	70	72	76	72	70	64	67	75	81	84

Monthly average number of precipitations (mm)

	January	February	March	April	May	June	July	August	September	October	November	December
1983	26.5	37.2	66.0	30.0	141.4	117.3	10.5	68.5	10.1	61.4	169.9	21.7
1984	6.5	44.4	85.6	120.5	59.3	37.6	82.2	16.1	13.6	59.7	36.6	17.4
1985	69.4	170.3	36.3	39.6	95.1	54.4	49.1	9.8	0.9	39.4	5.0	50.9
1986	90.6	81.2	25.7	54.9	170.6	65.3	26.7	17.6	35.4	75.8	87.9	39.9
1987	163.2	88.7	48.7	87.4	96.4	15.9	21.2	34.4	28.1	99.7	74.6	128.2
1988	76.5	73.3	89.4	83.0	134.0	97.5	71.2	34.6	22.1	71.8	51.2	83.4
1989	1.9	9.4	29.0	41.2	42.9	50.0	24.7	12.9	27.2	113.9	143.5	51.6
1990	27.7	23.6	4.1	161.7	95.7	20.1	23.7	21.4	13.9	84.4	67.3	31.5
1991	66.1	64.6	63.1	70.4	63.5	59.2	36.0	19.3	7.2	39.0	80.9	61.7
1992	53.1	128.7	16.0	48.6	59.0	127.5	40.3	19.0	65.3	15.6	82.8	56.1
1993	22.0	91.4	33.5	81.2	90.3	90.2	17.8	47.2	20.4	42.9	56.3	11.0
1994	26.4	56.0	50.2	88.7	109.0	82.0	34.3	27.6	18.3	31.7	115.6	53.6
***1998**	-	-	-	-	109.6	57.2	62.8	25.8	6.9	4.8	59.6	35.7
1999	0.0	-	-	-	79.2	109.5	42.3	31.8	57.5	65.2	45.3	23.8
2000	91.0	-	-	-	-	12.4	8.2	26.9	17.0	72.6	7.0	74.2
2001	**7.7**	69.7	102.5	92.0	110.1	22.6	68.8	35.3	0.0	76.0	51.3	114.7
2002	49.3	46.7	58.9	162.7	78.1	93.0	73.1	58.7	23.2	65.3	14.1	73.5
2003	40.3	75.2	113.2	152.9	53.3	79.4	78.9	55.2	31.7	121.6	86.3	48.9
2004	38.9	101.3	77.2	115.1	140.0	46.9	48.5	20.5	34.3	39.9	88.8	4.0
2005	62.2	51.9	172.4	81.9	125.3	82.0	19.1	43.6	68.7	72.2	38.1	40.5
2006	86.3	70.3	62.5	162.7	85.1	44.0	91.5	22.9	28.3	103.0	20.2	30.0
2007	50.3	58.2	77.0	192.5	75.4	74.5	89.4	38.3	0.5	65.4	123.6	31.8
2008	27.7	29.3	46.6	44.4	107.6	86.3	26.7	31.7	54.0	26.1	22.0	55.6
2009	26.0	40.6	113.4	110.8	93.1	80.3	136.1	62.4	129.5	18.6	54.5	60.7
2010	152.2	65.5	60.5	200.0	102.2	57.9	71.6	14.4	16.3	148.7	0.0	6.6
2011	58.1	103.7	76.7	182.1	120.8	29.7	54.2	27.9	19.8	52.6	45.0	17.9
2012	36.9	96.0	56.2	41.0	113.5	30.6	78.3	2.6	20.5	41.7	19.0	120.4

Total evaporation mm

	March	April	May	June	July	August	September	October	November	Year
1983	14.4	28.2	49.2	50.6	51.6	43.9	35.2	28.2	20.9	332.2
1984	19.0	27.5	42.1	51.9	55.1	42.0	40.6	28.4	18.9	374.3
1985	7.3	30.3	53.0	57.5	43.5	46.1	39.6	28.0	21.0	371.9
1986	14.4	30.8	42.7	49.2	52.3	48.3	44.9	30.1	16.6	381.9
1987	12.9	24.0	53.1	59.8	50.2	43.8	34.9	24.2	16.5	395.6
1988	16.2	27.6	44.2	50.8	47.1	39.9	34.7	30.2	16.2	352.5
1989	20.8	34.9	50.3	56.7	55.7	50.3	38.5	29.5	18.2	372.0
1990	17.3	25.7	47.0	55.5	52.2	43.2	40.8	30.1	20.4	369.1
1991	17.0	30.9	45.0	54.8	50.2	48.7	40.1	33.6	18.1	374.9
1992	10.2	25.0	42.3	49.2	46.4	41.0	34.5	31.0	16.8	309.0
1993	12.4	25.0	45.2	52.2	48.3	42.4	37.2	28.6	11.6	329.2
1994	16.6	31.3	47.3	51.2	45.5	43.7	39.4	32.8	18.8	368.2
1995										
1996										
1997	12.9	26.5	53.4	52.6	47.8	51.3	34.3	33.1	17.6	387.5
1998	15.8	30.3	53.4	64.9	52.0	49.5	38.8	33.3	22.9	404.8
1999	14.5	26.4	47.4	50.9	48.1	52.4	36.8	31.0	17.5	384.5
2000	14.5	26.6	47.4	52.1	48.2	48.8	39.9	29.0	17.3	369.1
2001	22.8	32.0	46.5	58.7	51.6	50.5	43.8	31.1	16.7	410.3
2002	19.3	25.0	43.3	53.3	50.1	46.2	43.5	34.0	20.4	370.6
2003	12.7	25.1	51.1	50.8	48.3	46.8	37.5	35.0	17.1	382.7
2004	19.5	24.7	45.8	53.3	44.8	48.7	37.5	30.8	17.6	368.6
2005	15.6	28.6	48.2	51.4	53.6	48.8	38.3	29.7	18.7	367.1
2006	18.5	30.0	51.5	69.8	48.2	58.1	39.5	33.3	17.1	401.9
2007	15.6	22.4	54.1	55.7	47.6	46.2	43.4	33.5	17.0	361.6
2008	23.2	35.0	44.4	51.0	49.9	49.4	39.8	31.2	18.6	344.9
2009	17.1	23.8	47.9	53.7	48.1	38.4	33.3	33.1	19.3	372.1
2010	22.0	27.4	47.6	63.9	56.9	49.6	45.9	33.1	19.8	450.8
2011	15.4	27.3	48.0	58.0	56.4	45.8	38.1	28.2	11.4	370.9
2012	10.1	31.7	52.7	60.2	50.0	52.1	41.5	34.0	21.0	393.8

Fantan (Latitude 40° 24′, Longitude 44° 41′, height 1800m.)

Monthly average temperature of air (°C)

	January	February	March	April	May	June	July	August	September	October	November	December
1983	-10.5	-8.1	-1.7	6.5	10.8	13.5	18.5	17.0	13.3	7.7	3.4	-2.9
1984	-4.2	-6.3	1.0	5.8	8.3	14.3	19.4	16.6	15.7	7.8	2.4	-7.7
1985	-5.5	-7.2	-5.8	7.5	12.4	16.1	15.9	18.6	15.1	7.1	4.8	-4.8
1986	-4.8	-3.3	-1.7	7.1	8.4	13.2	18.6	19.1	17.0	8.5	0.5	-5.1
1987	-2.2	-2.1	-2.7	3.7	12.8	16.4	18.3	17.7	13.4	4.6	1.1	-3.1
1988	-7.3	-5.7	-0.6	6.1	9.2	13.5	16.9	15.8	12.9	8.3	0.3	-2.5
1989	-9.6	-7.7	2.7	9.9	11.6	15.6	19.4	19.6	14.6	7.9	1.9	-2.6
1990	-8.5	-6.0	0.2	4.4	10.2	15.2	18.4	16.8	15.7	8.4	4.2	-2.3
1991	-6.9	-6.4	-0.1	7.6	9.5	14.7	18.2	18.4	15.0	10.2	2.3	-6.0
1992	-10.0	-	-4.0	4.3	8.3	12.8	16.4	16.1	12.4	9.2	0.7	-5.0
1993	-8.4	-7.6	-2.9	4.2	9.5	14.5	17.6	17.6	14.9	8.2	-3.0	-3.8
1994	-4.4	-6.3	0.0	8.6	10.6	14.0	16.8	17.6	15.0	9.6	2.1	-7.3
1995	-3.5	-2.5	1.7	6.4	12.0	15.0	17.6	19.3	14.6	7.4	2.7	-4.0
1996	-5.7	-3.2	-0.4	4.9	12.2	13.6	19.0	19.1	14.9	8.6	2.9	1.2
1997	-3.5	-6.1	-4.0	5.0	11.7	15.5	17.4	19.6	12.5	10.1	3.0	-3.4
1998	-6.4	-7.3	0.3	8.3	11.5	17.0	18.7	19.6	15.2	10.7	5.9	0.5
1999	-2.9	-1.5	1.3	6.3	10.9	14.9	17.7	20.7	14.3	9.2	1.3	-0.7
2000	-5.9	-5.1	-2.0	8.6	10.4	15.5	21.8	19.9	15.5	7.7	2.9	-2.8
2001	-5.4	-2.3	4.4	8.0	9.5	16.0	18.3	19.5	15.8	8.3	1.2	-2.2
2002	-6.6	-2.0	1.8	4.2	8.8	14.5	18.0	18.0	16.8	10.6	4.6	-7.6
2003	-4.1	-4.6	-3.1	4.6	11.8	14.0	17.8	18.6	13.9	11.1	1.7	-3.6
2004	-4.6	-3.4	2.4	4.5	10.0	14.9	17.0	19.4	14.7	9.9	2.3	-6.7
2005	-6.3	-6.4	-0.8	7.2	10.7	14.2	19.9	19.2	14.5	8.8	2.9	-0.2
2006	-7.7	-4.0	1.9	7.4	12.0	18.9	18.0	22.4	15.5	9.9	1.4	-5.3
2007	-7.7	-4.7	-0.8	2.6	12.8	15.5	17.8	18.4	16.9	10.5	1.1	-5.0
2008	-10.9	-7.3	4.9	10.2	9.6	14.3	18.6	20.1	15.6	9.5	3.0	-3.5
2009	-6.2	-1.2	0.3	3.8	11.0	14.8	17.8	15.7	12.3	10.6	3.2	-0.3
2010	-2.1	-1.0	3.3	5.6	10.7	17.6	20.3	19.9	17.5	10.3	5.2	1.9
2011	-5.0	-5.6	-0.3	5.7	10.5	15.9	20.2	18.3	14.1	7.6	-3.0	-5.2
2012	-4.8	-7.6	-4.0	8.2	12.4	16.4	18.1	20.4	15.7	10.7	4.6	-3.0

Monthly average relative humidity of air (%)

	January	February	March	April	May	June	July	August	September	October	November	December
1983	85	93	86	74	76	72	65	65	62	72	91	84
1984	87	87	88	80	75	64	60	62	56	73	89	90
1985	91	88	86	75	66	63	68	57	55	70	78	-
1986	87	93	82	87	81	74	66	58	55	71	89	88
1987	82	84	78	74	56	58	59	59	58	79	79	84
1988	88	88	79	72	71	72	68	71	64	66	65	71
1989	68	69	65	53	57	63	64	57	56	68	73	68
1990	70	72	59	68	63	58	64	64	51	61	63	70
1991	86	79	81	71	63	67	60	65	53	74	89	91
1992	85	-	83	70	-	-	-	-	-	-	-	-
1996	87	73	76	73	65	67	62	56	63	63	66	78
1997	64	70	63	59	62	61	70	59	62	65	69	80
1998	77	64	61	64	76	68	65	58	56	55	75	79
1999	74	61	63	67	62	72	67	58	65	62	76	69
2000	77	67	59	61	65	62	51	50	57	74	73	89
2001	80	69	67	63	73	64	65	59	53	65	77	89
2002	81	70	72	84	79	73	77	71	62	72	72	83
2003	89	88	85	78	63	72	69	64	65	69	74	75
2004	74	75	65	65	71	69	68	65	61	66	75	73
2005	75	75	73	65	73	71	68	70	69	71	74	74
2006	91	94	90	92	90	72	71	59	66	74	69	71
2007	74	73	75	74	68	67	68	66	61	66	72	72
2008	71	70	62	58	66	67	67	60	62	67	71	70
2009	71	71	64	65	63	68	68	68	71	65	70	74
2010	72	74	66	70	69	65	63	57	61	70	59	62
2011	75	73	63	69	69	65	65	66	66	65	73	71
2012	71	69	64	62	67	66	67	61	63	69	72	75

Monthly average number of precipitations (mm)

	January	February	March	April	May	June	July	August	Septembe	October	November	December
1983	22.3	37.5	39.9	23.2	171.6	143.9	4.1	28.9	12.6	71.6	175.8	21.1
1984	4.0	52.9	91.5	114.4	39.4	14.9	51.9	12.0	5.2	64.6	32.6	18.2
1985	54.5	133.6	39.2	33.3	102.1	39.0	30.0	2.7	2.6	42.6	6.3	46.5
1986	43.5	54.9	11.5	74.7	199.8	73.6	28.2	2.6	18.5	68.8	98.5	32.2
1987	132.2	94.9	49.3	99.2	94.0	14.8	30.2	22.6	25.0	97.9	70.9	149.9
1988	66.9	64.8	85.8	78.5	153.4	130.2	67.6	41.9	25.3	60.0	43.0	75.1
1989	0.4	8.4	28.4	38.2	41.8	78.7	25.3	5.3	29.8	137.6	150.6	52.2
1990	28.6	15.3	8.3	176.6	98.0	17.1	32.3	17.1	9.0	72.1	68.4	34.8
1991	55.6	47.7	42.6	83.0	83.3	46.6	83.3	9.3	0.7	43.1	102.2	56.9
1992	43.0	114.8	18.9	30.6	86.2	125.9	41.2	25.9	58.4	9.5	66.5	38.2
1993	22.4	67.3	35.9	97.6	139.1	80.6	24.1	27.0	19.9	32.9	51.1	15.4
1994	35.0	61.9	70.5	122.8	106.9	94.8	35.8	19.6	30.6	59.9	86.6	47.7
1995	16.0	16.3	50.9	108.9	73.8	117.8	12.9	1.7	80.5	31.2	53.0	3.8
1996	44.4	54.3	71.2	128.8	61.3	36.1	53.3	24.2	17.9	36.3	1.0	108.0
1997	14.5	53.1	75.2	63.3	77.8	20.9	58.5	12.6	29.2	71.7	30.9	61.7
1998	24.0	43.3	46.2	69.1	105.5	85.2	66.0	15.3	1.4	18.2	44.4	31.5
1999	0.6	56.2	58.4	43.9	65.7	123.3	46.9	24.0	88.8	56.5	30.2	19.6
2000	55.2	37.6	24.9	73.8	99.4	13.5	15.6	14.4	14.5	63.8	5.6	57.7
2001	5.7	27.2	89.8	104.5	100.9	20.3	64.9	30.9	0.0	55.0	33.8	111.0
2002	49.2	37.9	56.2	145.0	85.6	61.8	56.5	32.1	13.4	54.6	18.1	69.8
2003	33.6	57.2	89.6	125.6	43.1	50.3	86.5	53.2	14.8	95.0	100.1	42.0
2004	32.6	60.9	66.5	99.3	103.2	42.8	33.1	12.8	22.7	28.9	86.4	2.8
2005	56.3	32.2	130.1	102.4	103.5	87.0	13.0	43.2	68.5	65.8	34.5	48.8
2006	81.9	68.9	58.6	189.2	73.2	35.6	86.6	4.0	28.3	102.0	29.5	31.3
2007	40.5	59.8	99.8	191.1	64.5	85.5	86.0	60.1	0.0	55.8	111.0	25.5
2008	35.6	26.2	50.0	34.3	122.4	66.4	15.6	8.7	51.4	24.0	22.3	52.0
2009	29.0	46.4	91.9	113.9	70.6	81.8	132.8	27.8	112.6	21.8	60.0	73.1
2010	115.4	72.0	64.1	208.8	110.1	53.7	38.7	21.2	27.1	135.9	0.0	8.8
2011	60.7	80.0	56.7	183.7	119.2	30.7	61.2	17.9	23.5	45.8	36.7	16.5
2012	40.1	82.2	54.4	61.8	77.8	37.0	40.2	1.2	16.9	28.0	19.7	75.8

Total evaporation mm

	March	April	May	June	July	August	Septembe	October	November	Year
1983	14.1	32.2	55.1	49.2	50.5	38.2	35.8	33.9	21.7	341.4
1984	17.9	30.9	46.7	51.9	54.1	37.2	42.1	34.1	20.2	366.2
1985	7.9	34.5	61.7	58.8	42.1	42.6	40.5	32.5	23.8	372.9
1986	14.1	33.6	47.0	48.1	51.0	44.2	46.4	35.6	17.4	375.1
1987	12.7	26.8	63.0	60.1	50.0	39.9	35.9	27.6	18.2	383.3
1988	15.5	31.4	49.7	49.2	45.1	35.0	34.8	35.3	17.2	341.7
1989	20.2	40.3	58.4	56.6	53.9	45.7	39.2	34.4	19.5	383.9
1990	16.7	28.2	53.2	55.4	50.2	37.6	42.2	35.5	22.8	365.1
1991	16.3	34.7	50.5	53.4	49.5	42.1	40.3	39.9	20.0	371.2
1992	10.7	27.8	46.8	46.9	43.8	35.8	33.7	37.3	17.8	316.8
1993	12.4	27.8	50.7	52.6	47.6	39.7	39.9	35.0	12.5	337.5
1994	16.4	37.2	54.6	50.6	44.9	39.7	40.3	38.4	19.8	372.9
1995	18.8	32.2	59.8	54.4	47.5	44.9	39.2	33.3	20.5	394.5
1996	15.8	29.0	60.9	49.5	52.5	44.3	39.9	36.0	20.9	390.1
1997	10.8	29.2	58.6	56.3	46.8	45.7	33.8	39.7	21.1	380.0
1998	16.8	36.4	57.9	62.7	51.3	45.7	40.9	41.3	25.6	409.1
1999	18.1	31.9	55.6	54.0	47.7	49.3	38.3	37.4	18.6	401.3
2000	13.6	37.2	53.9	56.3	63.8	46.8	41.7	34.0	21.0	401.9
2001	22.7	35.7	50.5	58.4	49.9	45.6	42.4	35.2	18.4	399.6
2002	18.9	27.7	48.3	52.6	48.9	40.7	45.5	41.0	23.4	378.7
2003	12.1	28.5	59.1	50.6	48.3	42.7	37.4	42.4	19.1	379.4
2004	19.7	28.2	52.4	53.9	45.6	45.2	39.5	39.1	20.0	380.2
2005	15.3	33.9	54.8	51.6	55.7	44.6	38.8	36.4	20.9	384.2
2006	19.0	34.3	60.0	71.7	48.9	55.8	41.6	39.2	18.8	416.6
2007	15.4	24.9	63.3	56.4	48.0	42.0	46.0	40.8	18.2	381.3
2008	23.4	41.4	51.1	52.0	51.1	47.4	42.1	38.3	21.1	378.3
2009	16.9	26.9	55.8	53.8	48.0	34.7	33.4	41.2	21.3	373.6
2010	21.0	30.5	54.9	65.4	57.4	46.7	48.1	40.1	24.5	444.5
2011	16.1	30.7	54.3	57.9	56.9	41.8	37.9	33.7	12.4	374.4
2012	10.7	36.2	61.4	59.9	49.2	48.3	42.3	41.4	23.5	404.5

Ashtarak (Latitude 40° 17′, Longitude 44° 21′, height 1090m.)

Monthly average temperature of air (ºC)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1989	-6.1	-2.6	8.6	15.5	17.6	22.7	26.7	25.7	19.7	12.4	6.3	1.7
1990	-6.2	-1.7	5.8	10.0	15.4	21.2	25.3	22.9	20.9	12.9	7.8	1.8
1991	-3.2	-2.1	5.3	12.8	14.5	21.6	24.9	25.4	20.5	14.9	6.2	-1.1
1992	-6.7	-3.5	2.3	10.3	14.1	18.6	23.3	22.9	19.0	13.9	4.7	-1.0
1993	-5.9	-4.8	2.9	10.1	14.6	19.9	24.4	23.8	19.9	12.4	1.2	-3.4
1994	-2.1	-2.8	4.9	13.4	15.4	19.3	23.3	23.5	20.5	14.6	6.6	-5.0
1995	-2.2	0.2	6.4	11.3	17.7	20.8	24.5	26.0	20.6	12.2	6.6	-0.6
1996	-0.3	2.2	5.9	10.7	17.9	19.8	26.1	26.0	19.1	13.2	6.7	5.3
1997	1.4	-1.9	2.2	10.4	17.6	21.0	24.6	25.9	17.6	14.4	6.3	0.3
1998	-3.2	-3.2	5.3	13.4	16.4	23.3	25.2	26.4	21.0	14.8	9.5	4.3
1999	1.4	4.0	7.2	11.7	16.1	21.0	24.5	26.9	19.2	13.5	5.9	1.5
2000	-1.5	-0.4	4.4	14.3	16.1	21.7	28.0	25.4	21.3	13.1	6.5	1.3
2001	-2.9	2.9	9.6	12.9	15.4	23.3	26.1	26.4	21.9	13.2	4.7	2.1
2002	-2.7	2.9	7.0	9.7	14.4	20.6	24.8	24.4	22.3	15.0	7.3	-6.1
2003	-2.6	0.1	2.4	10.9	17.5	20.0	24.7	25.3	20.0	15.5	5.6	-0.2
2004	-2.0	1.0	7.9	10.1	15.5	21.6	24.0	26.3	20.5	14.1	6.5	-4.3
2005	-5.1	-2.3	4.7	13.0	16.2	20.6	26.7	26.1	20.5	13.4	6.5	0.4
2006	-4.4	-2.0	7.4	12.5	17.2	25.1	24.7	28.4	21.0	14.5	5.6	-4.5
2007	-9.6	-1.8	5.3	8.8	17.8	21.6	24.3	24.7	22.8	15.2	5.6	-0.9
2008	-10.4	-2.8	10.1	15.2	15.3	20.9	25.8	26.2	21.1	14.1	7.3	-0.3
2009	-5.1	3.6	5.7	9.4	16.1	21.3	24.6	22.3	18.3	15.6	7.0	3.4
2010	1.5	3.9	8.5	10.9	15.3	23.8	26.9	26.3	23.3	14.3	7.9	3.8
2011	-1.0	-0.4	6.0	11.2	15.5	21.8	26.9	24.8	20.0	12.1	1.8	-2.7
2012	-0.2	-4.0	1.9	13.9	17.9	22.9	24.2	26.8	21.2	15.6	8.9	1.0

Monthly average relative humidity of air (%)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1989	70	64	59	53	44	41	40	41	42	63	73	73
1990	81	75	56	69	62	55	55	60	60	69	72	79
1991	74	63	64	58	59	55	52	56	56	67	77	78
1992	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	55	49	55	85	97
1994	87	75	62	52	60	54	50	51	50	60	72	81
1995	81	72	50	56	55	56	54	52	58	66	65	69
1996	76	65	67	60	58	54	51	51	55	60	59	80
1997	62	74	57	55	56	56	55	51	59	66	68	83
1998	82	63	60	60	68	53	-	55	61	63	80	81
1999	72	59	56	61	59	59	52	50	61	64	71	81
2000	77	69	53	57	63	50	48	50	56	72	71	91
2001	87	63	67	69	69	50	59	52	56	70	65	74
2002	62	55	58	75	73	52	47	49	45	66	66	83
2003	92	82	69	72	66	63	61	51	50	64	73	83
2004	85	78	64	68	71	57	52	47	50	60	70	71
2005	76	70	65	56	61	56	49	50	52	55	64	82
2006	82	83	64	74	67	48	45	30	37	58	61	73
2007	81	69	65	65	62	54	50	50	47	55	63	69
2008	78	68	58	55	62	57	54	53	58	67	69	74
2009	77	69	61	63	62	58	57	59	65	61	73	79
2010	77	76	63	71	80	62	53	49	56	71	63	68
2011	79	74	59	75	76	62	54	59	64	75	81	88
2012	82	81	71	70	75	68	74	66	71	80	87	91

Monthly average number of precipitations (mm)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	6.4	16.6	27.5	20.4	47.9	63.4	13.6	22.0	2.7	35.9	66.8	-
1984	10.6	25.3	69.3	61.9	24.2	8.3	23.9	9.6	2.1	48.3	18.5	-
1985	55.8	82.3	45.5	35.6	29.7	29.4	11.1	5.5	0.0	31.9	9.2	43.7
1986	25.3	28.8	20.3	24.5	112.0	43.6	29.8	8.6	11.7	36.9	63.9	8.2
1987	41.4	49.8	24.5	48.1	58.6	4.7	6.7	15.6	14.8	108.7	32.0	94.6
1988	63.7	16.8	37.0	55.9	85.8	91.6	24.4	23.0	5.8	44.4	14.6	34.3
1989	0.8	1.6	7.2	24.0	18.9	7.4	8.2	10.6	12.8	82.5	64.7	16.9
1990	22.5	6.9	1.0	85.3	34.5	14.0	17.3	19.1	10.6	33.8	24.4	18.6
1991	51.3	16.7	44.1	25.7	51.4	21.8	15.5	1.7	0.9	28.3	75.5	41.2
1992	33.2	62.7	27.1	28.2	40.9	57.1	7.3	7.9	21.6	4.0	45.1	44.1
1993	34.1	44.4	24.9	35.1	79.7	38.4	9.0	12.2	2.1	17.3	70.5	18.3
1994	26.7	75.9	40.5	100.9	102.8	44.1	10.1	8.7	15.0	30.4	63.4	45.4
1995	19.0	13.8	29.1	62.8	49.8	38.5	4.3	1.6	52.6	10.2	22.3	0.3
1996	41.5	22.4	25.3	77.4	42.1	20.3	21.1	4.2	14.7	24.2	0.0	60.4
1997	8.7	31.0	20.0	42.8	27.6	21.4	22.0	8.0	20.9	44.2	24.2	43.6
1998	29.5	19.0	23.6	39.8	73.5	34.2	22.2	2.4	1.0	3.8	27.3	10.4
1999	4.0	11.9	55.5	28.8	60.3	41.9	59.4	3.1	28.7	29.7	12.2	12.1
2000	46.3	21.6	12.2	37.1	62.8	4.8	10.3	3.1	4.0	34.0	1.2	22.8
2001	10.6	13.1	50.8	74.2	51.8	12.5	14.6	22.2	1.0	49.4	28.4	50.1
2002	9.9	15.8	19.6	115.5	58.1	40.2	54.0	23.1	20.0	24.2	10.8	58.8
2003	27.2	57.7	74.8	74.8	55.4	55.4	50.1	25.1	19.4	58.3	82.9	22.7
2004	26.5	31.7	29.2	64.4	51.9	24.9	10.5	3.0	12.3	24.2	49.7	1.9
2005	37.3	11.8	68.4	78.0	61.8	33.5	4.8	25.3	27.2	37.2	38.1	30.1
2006	56.1	40.4	8.7	110.6	58.9	36.0	32.9	4.2	15.2	67.0	9.2	26.1
2007	13.5	9.9	74.9	92.9	43.0	42.7	31.9	56.3	0.1	38.9	46.8	11.7
2008	24.6	8.6	18.7	7.6	58.0	50.3	12.0	11.5	42.8	19.2	13.0	35.4
2009	10.7	33.1	51.0	92.5	35.7	40.7	38.4	13.8	44.2	21.0	23.2	37.1
2010	62.4	35.7	16.6	117.8	135.6	4.5	32.3	0.3	3.8	81.1	0.0	0.3
2011	36.0	53.8	33.8	88.1	102.4	22.3	14.5	14.3	24.2	55.1	17.0	10.4
2012	12.4	66.6	13.7	43.6	41.1	24.9	33.1	0.1	14.7	34.5	10.3	47.0

Total evaporation mm

	March	April	May	June	July	August	September	October	November	Year
1989	31.1	**53.6**	63.0	61.1	61.1	48.8	41.3	32.3	24.1	445.5
1990	25.9	**36.9**	53.9	54.7	55.1	40.2	45.0	33.4	26.5	400.7
1991	25.0	**44.7**	50.6	56.3	53.7	47.9	43.8	38.2	23.8	426.3
1992	20.4	**37.8**	49.3	45.4	48.1	40.2	39.3	35.8	21.6	363.2
1993	21.2	**37.3**	51.0	49.9	51.8	42.9	42.0	32.2	16.9	373.3
1994	24.3	**46.4**	54.0	48.0	48.2	42.0	43.9	37.6	24.5	414.7
1995	26.9	**40.4**	63.2	53.2	52.2	49.8	44.2	31.9	24.5	434.3
1996	26.1	**38.8**	64.0	49.6	58.4	49.9	39.8	34.2	24.6	442.7
1997	20.2	**38.0**	63.1	53.9	52.6	49.5	35.6	37.0	24.0	435.4
1998	25.1	**46.6**	57.8	63.7	54.8	51.3	45.4	37.9	29.7	454.6
1999	28.4	**41.5**	56.6	54.1	52.2	53.2	39.9	34.7	23.4	449.3
2000	23.5	**49.6**	56.5	56.8	66.5	47.8	46.4	33.8	24.3	455.6
2001	33.2	**44.8**	53.9	63.5	58.3	51.4	48.4	34.0	21.6	455.9
2002	27.9	**36.2**	50.2	52.4	53.5	44.7	49.7	38.7	25.6	425.7
2003	20.5	**39.1**	62.3	50.3	53.1	47.7	42.3	40.0	22.9	424.5
2004	29.7	**37.2**	54.4	56.5	50.6	51.0	43.7	36.3	24.4	432.6
2005	24.0	**45.4**	57.1	52.3	60.8	50.3	43.8	34.6	24.4	426.6
2006	28.8	**43.7**	61.1	72.2	52.9	59.0	45.4	37.2	22.9	459.8
2007	25.0	**34.1**	63.7	56.3	51.6	45.5	51.4	39.1	22.9	399.5
2008	34.4	**52.8**	53.4	53.7	57.0	50.7	45.6	36.2	25.6	413.6
2009	25.6	**35.6**	56.7	55.0	52.8	38.6	37.5	40.3	25.1	405.0
2010	30.9	**39.2**	53.4	66.0	61.8	50.9	53.3	36.8	26.7	484.6
2011	26.3	**40.1**	54.4	57.1	61.6	46.1	42.3	31.6	17.6	429.5
2012	19.7	**48.2**	64.4	61.8	51.3	52.7	46.1	40.2	28.5	466.9

Yeghvard (Latitude 40° 19′, Longitude 44° 29′, height 1337m.)

Monthly average temperature of air (ºC)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	-9.9	-5.8	1.8	10.0	14.3	17.5	23.2	21.7	17.2	11.0	6.2	-0.2
1984	-1.7	-2.8	4.5	9.2	12.0	18.8	24.1	21.3	19.6	11.1	5.3	-5.0
1985	-4.3	-4.5	-3.6	11.0	16.3	20.3	20.8	23.0	19.1	10.5	7.4	-2.5
1986	-3.7	-0.8	1.9	11.1	11.9	17.4	23.4	23.6	20.8	11.5	3.5	-1.8
1987	0.1	0.8	1.1	7.4	16.0	20.6	22.9	21.8	17.3	7.9	3.7	-0.3
1988	-5.9	-2.6	3.2	9.8	12.5	17.4	21.5	20.2	17.3	11.3	3.2	0.2
1989	-7.7	-4.7	6.2	13.4	15.5	20.3	24.5	23.9	18.5	11.0	4.8	-0.1
1990	-7.3	-3.0	3.8	7.7	13.5	19.4	23.3	21.6	19.8	11.7	6.3	0.1
1991	-4.8	-4.3	3.5	11.0	12.8	19.3	23.0	23.4	19.4	13.8	5.1	-2.8
1992	-8.9	-3.0	2.3	8.2	12.2	16.7	21.4	20.8	16.8	12.2	4.7	-2.0
1993	-7.3	-6.1	0.5	8.2	12.9	18.2	22.5	22.1	19.0	11.3	0.0	-4.3
1994	-3.2	-4.5	3.1	12.1	14.1	18.4	21.7	22.3	19.1	12.9	5.1	-6.0
1995	-2.4	-0.9	5.5	9.8	15.8	19.4	22.5	23.8	18.5	10.7	5.3	-2.0
1996	-2.8	-0.4	3.4	8.6	16.1	18.3	24.0	23.9	18.5	12.1	5.2	3.8
1997	-1.0	-3.0	2.0	8.7	15.5	20.3	22.2	24.0	16.5	13.4	5.0	-1.4
1998	-5.6	-5.7	3.5	11.6	15.3	21.9	23.1	24.2	19.4	13.7	8.0	3.2
1999	-0.6	1.5	5.6	9.8	14.5	19.6	22.7	25.2	18.0	12.8	4.6	1.2
2000	-4.0	-3.4	2.8	12.3	14.1	20.3	26.6	24.2	19.7	11.4	5.0	-0.1
2001*	-3.7	0.9	7.7	11.2	13.5	20.9	23.5	24.2	20.2	11.6	3.5	0.5
2008	-	-	-	-	-	-	-	23.9	19.1	12.7	5.8	-1.7
2009	-5.9	1.6	3.8	7.3	14.1	18.9	21.9	19.7	16.0	13.9	5.9	2.5
2010	0.2	2.4	6.8	8.8	13.3	21.4	24.4	23.9	21.3	13.0	6.9	3.1
2011	-2.6	-2.5	3.8	9.1	13.5	19.3	24.4	22.5	17.9	10.7	0.1	-4.1
2012	-1.6	-6.0	-0.8	11.6	15.7	20.6	22.1	24.5	19.4	14.2	7.5	-0.1

Monthly average relative humidity of air (%)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	68	67	59	51	60	57	49	50	48	53	77	70
1984	67	66	70	62	60	49	47	48	46	56	70	67
1985	76	77	68	58	54	48	50	42	43	59	67	71
1986	71	71	56	57	67	59	50	45	45	67	76	68
1987	68	72	64	59	51	48	47	50	46	67	68	76
1988	85	76	67	58	64	62	56	57	49	68	70	76
1989	70	66	62	51	52	54	49	49	51	72	79	72
1990	76	73	50	71	64	51	51	52	47	64	72	79
1991	74	68	66	61	58	57	50	53	50	60	80	81
1992	79	-	67	57	-	-	-	-	-	-	-	-
1996	71	61	67	64	59	51	48	43	49	58	59	76
1997	65	68	62	55	56	50	52	46	52	62	68	76
1998	73	64	61	57	65	56	54	46	50	50	68	71
1999	66	55	55	57	52	53	49	45	53	55	62	68
2000	70	65	65	55	59	46	38	43	44	56	60	77
2001	79	59	60	61	59	45	46	44	42	56	63	74
2008*	-	-	-	-	-	-	-	47	54	63	68	78
2009	73	71	63	65	60	60	61	61	65	60	74	77
2010	78	80	64	75	74	55	53	46	51	73	62	66
2011	78	72	58	69	70	60	52	53	55	63	74	76
2012	67	71	59	61	62	54	57	47	53	61	70	78

Monthly average number of precipitations (mm)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	14.3	33.9	35.4	11.2	68.2	70.7	16.0	17.9	5.4	43.8	97.4	11.6
1984	6.6	45.2	79.5	79.6	31.0	10.2	15.7	7.0	0.8	51.0	10.9	13.3
1985	63.4	111.6	44.2	28.7	30.7	21.4	22.3	0.5	1.1	33.5	5.2	41.8
1986	21.2	26.5	16.6	34.7	108.6	43.8	25.9	1.4	7.7	46.2	67.9	12.8
1987	78.3	53.8	42.2	52.1	78.6	6.0	3.7	25.9	14.0	86.0	37.6	106.0
1988	62.9	28.4	39.9	42.1	109.5	75.5	18.5	37.7	13.1	47.1	22.2	46.8
1989	0.2	2.1	16.0	20.4	27.7	18.0	13.8	2.1	17.0	102.3	89.5	22.5
1990	24.0	7.0	2.8	123.0	62.6	20.8	16.6	11.1	8.3	47.6	32.7	22.5
1991	52.1	22.8	35.5	42.4	54.4	58.5	40.7	9.9	1.5	22.7	76.2	31.6
1992	37.9	77.8	32.1	26.5	61.7	81.1	15.1	17.8	30.9	5.3	56.7	41.9
1993	27.5	49.3	33.7	40.3	87.3	37.2	11.8	8.4	3.7	28.1	56.9	12.7
1994	28.0	64.8	43.1	140.2	63.8	50.7	13.6	10.3	16.8	32.8	70.6	36.4
1995	19.3	16.3	47.8	87.9	46.7	28.8	7.1	22.0	68.6	14.3	30.2	0.3
1996	37.3	31.6	40.9	92.6	46.3	18.6	58.8	1.1	15.3	32.1	0.0	62.4
1997	9.1	31.2	49.6	44.5	43.2	33.5	33.4	7.9	12.4	52.6	21.4	48.7
1998	28.3	42.8	29.1	47.4	92.5	44.5	60.9	1.8	2.9	4.4	35.8	19.2
1999	0.9	20.1	48.0	37.4	52.0	47.5	71.4	28.1	32.6	39.1	16.1	13.9
2000	51.6	24.9	14.7	42.7	75.4	15.3	16.7	6.7	7.9	43.7	4.0	42.2
2001	6.5	21.6	65.1	63.6	50.5	12.5	13.4	28.2	0.0	58.5	30.7	71.4
2002	23.0	20.0	29.0	122.0	66.0	59.0	23.0	27.0	8.0	36.0	14.0	51.0
2003	24.0	45.0	72.0	70.0	37.0	54.0	27.0	20.0	11.0	48.0	46.0	18.0
2004	25.6	21.9	33.5	42.4	66.3	32.9	34.5	11.1	15.7	32.3	26.5	3.3
***2008**	-	-	-	-	-	-	-	7.1	41.4	11.2	14.5	37.3
2009	23.7	35.9	54.4	95.2	35.5	42.7	89.2	12.8	82.4	13.8	26.6	44.2
2010	74.8	48.0	41.4	139.8	98.4	16.2	48.3	1.9	3.9	92.5	0.0	3.8
2011	41.3	53.7	35.4	103.1	131.3	33.0	36.1	21.0	6.1	37.7	21.4	9.9
2012	25.0	69.5	20.3	35.2	35.8	48.6	43.8	1.1	17.6	23.7	14.2	69.0

Total evaporation mm

	March	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	Year
1983	19.8	39.0	55.3	49.8	52.4	44.8	35.9	33.6	22.7	364.4
1984	24.0	36.9	47.2	54.5	55.9	43.5	42.5	33.9	21.4	397.8
1985	11.9	41.7	63.6	60.7	44.3	49.1	41.0	32.5	24.6	399.3
1986	20.0	41.9	46.9	49.4	53.2	51.2	46.3	34.8	19.0	399.0
1987	18.8	32.8	62.2	62.0	51.4	45.1	36.1	27.4	19.2	403.3
1988	21.9	38.4	48.9	49.4	46.5	40.3	36.1	34.3	18.6	363.3
1989	26.8	49.1	60.1	60.7	57.4	52.3	39.3	33.6	20.7	420.5
1990	22.9	33.5	52.3	56.9	52.8	44.5	43.1	35.3	22.9	388.1
1991	22.4	41.7	49.9	56.5	51.7	50.5	41.9	40.7	21.1	405.2
1992	20.6	34.7	48.0	47.1	46.3	41.9	34.7	36.4	20.6	348.2
1993	17.9	34.5	50.1	52.3	50.0	46.0	40.8	34.2	14.6	358.7
1994	21.8	45.0	54.7	53.0	47.0	46.9	41.0	38.3	21.1	400.3
1995	25.7	38.4	61.6	57.1	50.1	52.0	39.4	33.1	21.4	418.1
1996	22.3	35.5	62.7	52.7	55.5	52.5	39.3	36.3	21.3	419.0
1997	20.1	35.7	60.1	60.7	48.9	52.7	34.1	39.6	21.0	413.6
1998	22.4	43.4	59.3	67.9	52.1	53.4	41.9	40.4	25.6	433.1
1999	25.8	38.4	56.1	57.7	50.6	57.3	37.9	38.0	20.5	430.2
2000	21.4	45.6	54.4	60.5	66.4	53.6	42.9	34.5	21.0	433.3
2001	29.6	42.3	52.3	63.4	53.4	53.4	44.2	35.0	18.9	431.6
2008						52.3	40.9	37.8	22.1	156.5
2009	22.9	32.5	54.4	54.8	47.7	38.8	33.0	41.1	22.3	382.0
2010	28.0	36.0	51.7	65.8	57.0	52.2	48.1	38.4	23.8	452.4
2011	22.8	36.7	52.3	56.4	57.0	47.3	37.8	33.0	14.7	394.3
2012	16.1	43.3	61.1	62.0	48.4	54.6	41.8	41.7	24.7	429.4

Yerevan Agro (Merdzavan) (Latitude 40° 11′, Longitude 44° 24′, height 942m.)

Monthly average temperature of air (ºC)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	-11.6	-4.5	4.5	13.0	17.1	19.4	26.1	24.5	19.5	13.2	8.0	0.1
1984	-0.9	-1.2	7.3	11.8	14.9	22.1	26.7	24.0	21.9	12.6	6.7	-4.1
1985	-4.6	-3.0	-2.6	13.7	19.4	23.6	23.8	25.8	21.0	11.9	7.5	-1.5
1986	-3.7	1.1	4.7	14.1	14.4	20.4	26.4	26.2	22.5	12.7	5.2	-0.2
1987	1.7	2.9	3.7	9.7	18.6	23.4	25.8	24.3	19.4	10.2	4.0	0.8
1988	-4.9	0.2	5.8	12.3	15.0	20.3	24.5	23.0	19.6	13.3	3.8	0.5
1989	-9.0	-4.1	8.7	15.3	18.2	23.2	27.3	26.3	19.9	12.6	6.1	-0.2
1990	-8.1	-2.4	5.4	10.2	15.9	21.7	26.4	24.5	20.9	12.9	6.0	-0.1
1991	-5.2	-4.0	5.6	13.4	15.7	22.1	25.4	25.7	20.7	-	5.3	-
1992	-7.8	-3.6	2.5	10.7	15.2	19.6	23.3	23.4	19.1	12.8	3.4	-2.5
1993	-8.2	-5.6	2.9	10.6	15.4	21.2	25.4	24.7	20.8	12.2	1.5	-3.4
1994	-3.1	-2.6	5.6	14.7	16.8	21.0	24.7	24.7	21.3	14.5	5.8	-6.6
1995	-4.4	0.2	7.3	12.2	18.8	22.0	25.3	26.6	21.0	12.5	6.9	-1.9
1996	-0.5	1.4	6.2	11.5	19.4	21.3	27.2	26.9	20.2	13.8	5.3	4.8
1997	0.8	-2.6	2.8	11.7	18.9	22.5	24.9	26.8	18.4	15.0	5.3	-0.3
1998	-5.4	-3.8	6.7	14.5	18.1	24.3	26.0	26.8	21.5	15.0	9.3	3.5
1999	0.5	4.5	8.1	12.6	17.5	**22.3**	26.0	28.2	20.6	14.5	6.6	1.1
2000	-1.1	-0.5	4.9	15.4	17.0	22.5	29.5	26.9	21.9	13.3	5.7	1.0
2001	-2.5	2.3	9.7	13.1	15.8	23.3	26.4	27.0	22.1	12.7	4.5	1.7
2002	-3.4	3.1	7.8	12.1	15.0	21.0	25.8	24.9	22.7	14.8	6.2	-7.4
2003	-3.8	0.1	3.0	11.0	18.3	20.7	25.3	26.2	20.8	15.6	5.8	-0.2
2004	-2.9	1.3	7.8	10.8	16.0	21.5	24.4	27.1	20.8	13.6	6.6	-4.8
2005	-7.2	-2.6	5.6	13.9	17.2	21.6	27.8	27.2	21.5	13.8	6.6	-0.1
2006	-4.6	-2.8	8.1	13.4	18.4	26.3	25.9	29.2	21.8	15.0	5.4	-5.7
2007	-11.0	-2.6	6.4	9.6	18.7	22.6	25.5	25.7	23.5	15.8	5.7	-1.3
2008	-11.8	-2.3	10.6	16.1	16.2	22.0	26.7	27.0	22.0	14.6	7.0	-1.4
2009	-7.4	3.8	6.3	10.3	17.3	22.0	25.1	22.9	18.9	15.4	7.4	3.1
2010	2.0	4.4	9.3	11.4	16.1	24.6	27.8	27.3	24.1	14.9	6.0	1.8
2011	-1.2	-0.3	6.7	12.1	16.5	22.7	27.8	25.9	20.8	12.9	2.4	-2.8
2012	-0.3	-5.3	2.4	14.8	19.0	24.0	25.5	27.8	22.0	16.3	8.6	0.9

Monthly average relative humidity of air (%)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	78	77	66	55	58	57	45	47	50	58	76	79
1984	74	74	71	65	64	52	48	52	46	60	76	81
1985	85	75	74	62	56	52	50	46	49	59	68	77
1986	77	76	62	54	60	53	40	39	45	65	77	71
1987	71	77	64	56	52	50	43	45	46	58	73	78
1988	82	71	65	59	63	50	39	49	42	54	63	71
1989	66	63	53	53	51	50	38	33	44	62	66	73
1990	77	72	54	66	57	50	47	44	48	56	67	73
1991	73	67	65	56	58	53	54	52	51	64	72	86
1993*	-	75	-	-	65	-	52	54	53	59	80	81
1994	78	71	62	54	58	52	48	48	50	59	71	75
1995	74	72	52	55	45	35	32	33	43	55	56	64
1996	66	60	64	55	49	48	40	37	40	43	54	73
1997	67	60	65	47	48	46	48	40	45	59	63	66
1998	65	51	49	42	43	34	29	33	35	40	57	59
1999	54	46	46	46	43	39	36	38	46	48	52	63
2000	61	57	44	48	54	51	43	35	39	55	68	81
2001	78	59	58	59	57	42	36	37	36	49	63	69
2002	62	53	52	68	59	49	48	47	46	57	63	71
2003	75	66	60	62	49	52	47	44	50	63	75	80
2004	83	71	58	55	61	49	44	42	46	60	73	76
2005	75	66	64	52	58	49	41	43	47	55	69	89
2006	81	80	56	63	54	39	46	36	44	70	63	75
2007	83	74	64	65	56	49	47	47	42	57	75	82
2008	78	72	53	46	55	46	42	40	48	64	71	83
2009	85	73	62	59	55	50	50	49	59	60	74	82
2010	83	80	62	70	67	47	43	36	45	72	69	74
2011	81	79	57	65	64	51	42	44	49	61	72	80
2012	73	76	64	54	54	44	47	38	46	57	73	83

Monthly average number of precipitations (mm)

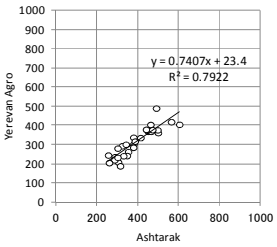
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	10.9	24.4	26.2	11.7	48.9	65.3	3.2	8.2	3.4	33.3	51.4	7.0
1984	12.5	24.6	60.4	47.0	53.9	4.5	17.7	6.2	1.1	36.6	8.5	8.8
1985	42.0	81.8	41.3	15.2	15.6	21.5	23.4	0.5	1.0	19.5	5.9	36.1
1986	20.7	19.1	17.9	33.4	70.1	25.8	43.8	0.4	5.9	29.4	61.1	9.1
1987	27.4	28.9	24.1	40.8	31.1	1.9	9.1	9.0	2.1	87.7	26.9	73.6
1988	40.1	12.9	48.2	31.0	66.6	38.0	12.6	28.6	8.7	37.9	9.0	43.4
1989	0.2	2.2	11.7	22.0	26.4	11.6	8.7	10.4	16.6	74.2	47.5	14.2
1990	20.9	6.3	0.0	67.0	50.4	12.3	5.4	9.3	2.0	29.8	18.6	15.1
1991	49.7	7.3	52.3	23.8	20.5	25.8	18.0	9.4	0.8	-	66.2	-
1992	23.4	42.5	22.8	20.7	33.6	72.0	5.3	14.5	30.2	4.6	49.9	18.9
1993	26.9	33.3	10.1	22.9	64.2	-	27.1	10.8	4.2	20.6	85.0	13.1
1994	27.1	55.3	33.1	60.4	58.5	40.8	10.5	2.2	13.4	25.7	59.7	32.8
1995	15.5	7.5	20.7	45.8	38.9	22.6	4.2	0.4	35.6	7.2	10.8	0.0
1996	21.2	21.8	37.0	63.0	32.5	38.5	1.1	0.0	8.3	21.3	0.0	19.0
1997	8.6	19.8	19.8	17.6	20.7	19.1	25.9	6.2	5.0	17.2	6.8	22.5
1998	21.3	15.1	13.5	16.2	63.8	26.5	26.3	0.4	0.4	6.2	24.3	6.8
1999	0.9	16.8	25.1	23.0	36.0	41.4	41.8	3.2	30.0	13.5	2.7	8.7
2000	32.1	9.5	15.5	35.1	52.0	5.3	1.4	0.8	4.9	28.2	1.0	20.3
2001	5.8	6.8	55.2	68.7	40.4	10.2	7.5	9.8	0.0	27.7	20.0	34.1
2002	12.1	4.8	16.0	106.7	69.6	35.2	35.3	14.6	1.8	28.4	8.7	36.5
2003	15.8	35.4	68.8	42.3	11.3	47.6	31.1	20.8	15.7	46.2	57.9	13.1
2004	25.4	22.0	26.4	47.7	50.5	19.9	7.4	0.8	5.4	14.8	20.4	1.3
2005	44.8	9.2	61.4	56.9	73.6	30.7	4.4	11.6	16.2	14.3	23.9	26.0
2006	44.3	42.3	9.4	100.7	37.7	9.3	31.5	0.5	4.5	51.7	7.6	30.1
2007	23.2	9.2	55.3	98.2	24.8	37.1	28.1	33.4	0.0	37.2	49.6	8.8
2008	22.8	11.5	12.9	10.9	55.2	32.8	2.8	4.3	34.9	10.3	9.8	25.5
2009	13.2	24.8	30.8	59.2	29.1	22.3	62.4	20.5	59.3	12.4	21.0	24.8
2010	48.8	47.9	17.8	114.4	109.4	13.8	20.8	2.3	22.6	90.9	0.0	1.9
2011	29.4	45.5	24.0	87.0	78.7	25.0	18.8	6.1	19.7	23.6	10.9	9.3
2012	11.1	52.4	8.7	32.7	22.9	50.4	47.0	2.1	5.7	7.2	12.7	49.2

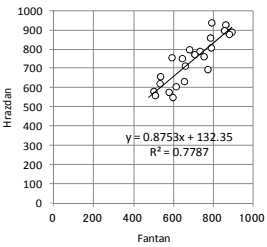
Total evaporation mm

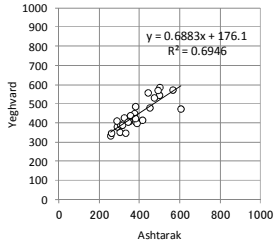
	March	April	May	June	July	August	September	October	November	Year
1983	24.5	46.1	59.9	47.4	56.4	43.3	41.1	36.5	27.6	382.2
1984	29.5	42.5	51.4	57.4	58.7	41.8	48.7	35.0	25.3	428.1
1985	13.7	48.3	70.5	63.8	48.0	47.4	45.7	33.4	26.7	424.8
1986	24.8	49.7	49.6	50.9	57.5	48.7	50.8	35.3	22.9	422.3
1987	23.2	36.9	66.6	62.9	55.2	42.7	40.8	29.8	21.1	427.7
1988	26.7	43.9	51.7	50.5	50.4	39.0	41.4	36.8	20.9	389.5
1989	32.3	54.0	64.8	62.0	61.2	49.0	42.2	35.0	24.3	436.4
1990	26.0	38.1	55.1	55.8	57.5	43.3	45.3	35.8	24.2	396.9
1991	26.4	47.4	54.3	57.4	53.7	47.1	44.7	36.0	23.1	415.4
1992	21.3	39.4	52.5	48.1	46.4	40.1	39.9	35.5	20.3	359.1
1993	21.9	39.2	53.2	53.8	53.7	43.9	45.0	34.1	17.7	375.4
1994	26.4	51.8	58.7	53.1	51.1	43.9	46.6	39.9	23.9	425.4
1995	29.5	43.6	67.6	57.0	53.3	50.1	45.7	34.8	25.6	436.2
1996	27.4	41.6	70.5	54.2	60.8	51.1	43.2	38.0	23.1	453.2
1997	21.8	42.2	68.1	59.0	51.9	50.8	38.0	41.3	23.1	439.5
1998	28.3	51.1	64.3	67.0	56.0	50.8	47.3	41.3	30.0	462.2
1999	31.1	44.8	61.7	58.2	56.0	55.9	44.4	39.9	25.1	463.0
2000	25.2	54.4	59.5	59.0	71.0	51.1	48.7	36.8	23.7	468.8
2001	34.5	46.4	54.7	62.4	57.5	51.5	49.4	35.3	21.9	450.4
2002	30.5	43.3	51.7	53.1	55.2	44.5	51.5	40.8	24.5	426.1
2003	22.1	40.2	65.2	52.0	53.3	48.7	45.0	43.1	23.9	425.0
2004	30.5	39.6	55.5	55.2	49.9	51.9	44.9	37.5	25.1	422.8
2005	26.3	49.1	60.4	55.4	63.3	52.2	47.3	38.2	25.1	436.5
2006	31.0	47.2	65.7	77.1	55.5	59.9	48.4	41.4	23.2	475.2
2007	27.7	36.7	67.3	59.6	54.1	47.1	54.7	43.6	23.7	417.2
2008	36.7	57.0	56.4	57.1	58.9	51.4	49.0	40.4	25.9	431.7
2009	27.7	38.5	61.0	56.9	52.5	38.7	39.3	42.4	26.5	405.5
2010	33.6	41.5	55.8	68.3	63.2	52.4	56.9	41.0	24.2	487.2
2011	28.3	43.3	57.4	60.0	63.4	47.7	45.0	35.8	18.9	437.4
2012	21.2	52.3	68.7	65.6	54.1	54.3	49.2	45.2	28.7	479.0

(3) Correlation of Precipitation Data between each observation point (Appendix D-3)

	Fantan	Hrazdan	Ashtarak	Yeghvar	Yerevan
1983	753	760.5	323.2	425.8	293.9
1984	502	579.5	302	350.8	281.8
1985	532	620.2	379.7	404.4	303.8
1986	707	771.6	413.6	413.3	336.7
1987	881	886.5	499.5	584.2	362.6
1988	893	888	497.3	543.7	377
1989	597	548.2	255.6	331.6	245.7
1990	578	575.1	288	379	237.1
1991	654	631	374.1	448.3	
1992	659	712	379.2	484.8	338.4
1993	613	604.2	386	396.9	318.2
1994	772	693.4	563.9	571.1	419.5
1995	567		304.3	389.3	209.2
1996	637		353.6	437	263.7
1997	569		314.4	387.5	189.2
1998	550		286.7	409.6	220.8
1999	614		347.6	407.1	243.1
2000	476		260.2	345.8	206.1
2001	644	750.7	378.7	422	286.2
2002	680	796.6	450	478	369.7
2003	791	936.9	603.8	472	406
2004	592	755.4	330.2	346	242
2005	785	857.9	453.5		373
2006	789	806.8	465.3		369.6
2007	880	876.9	462.6		404.9
2008	509	558	301.7		233.7
2009	862	926	441.4	556.4	379.8
2010	856	895.9	490.4	569	490.6
2011	733	788.5	471.9	530	378
2012	535	656.7	342	403.8	302.1







Monthly precipitation (mm)

Hrazdan

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1983	26.5	37.2	66.0	30.0	141.4	117.3	10.5	68.5	10.1	61.4	169.9	21.7	760.5
1984	6.5	44.4	85.6	120.5	59.3	37.6	82.2	16.1	13.6	59.7	36.6	17.4	579.5
1985	69.4	170.3	36.3	39.6	95.1	54.4	49.1	9.8	0.9	39.4	5.0	50.9	620.2
1986	90.6	81.2	25.7	54.9	170.6	65.3	26.7	17.6	35.4	75.8	87.9	39.9	771.6
1987	163.2	88.7	48.7	87.4	96.4	15.9	21.2	34.4	28.1	99.7	74.6	128.2	886.5
1988	76.5	73.3	89.4	83.0	134.0	97.5	71.2	34.6	22.1	71.8	51.2	83.4	888.0
1989	1.9	9.4	29.0	41.2	42.9	50.0	24.7	12.9	27.2	113.9	143.5	51.6	548.2
1990	27.7	23.6	4.1	161.7	95.7	20.1	23.7	21.4	13.9	84.4	67.3	31.5	575.1
1991	66.1	64.6	63.1	70.4	63.5	59.2	36.0	19.3	7.2	39.0	80.9	61.7	631.0
1992	53.1	128.7	16.0	48.6	59.0	127.5	40.3	19.0	65.3	15.6	82.8	56.1	712.0
1993	22.0	91.4	33.5	81.2	90.3	90.2	17.8	47.2	20.4	42.9	56.3	11.0	604.2
1994	26.4	56.0	50.2	88.7	109.0	82.0	34.3	27.6	18.3	31.7	115.6	53.6	693.4
*1995	-	-	-	-	-	-	-	-	-	-	-	-	628.0
*1996	-	-	-	-	-	-	-	-	-	-	-	-	690.0
*1997	-	-	-	-	-	-	-	-	-	-	-	-	631.0
*1998	-	-	-	-	109.6	57.2	62.8	25.8	6.9	4.8	59.6	35.7	614.0
*1999	0.0	-	-	-	79.2	109.5	42.3	31.8	57.5	65.2	45.3	23.8	670.0
*2000	91.0	-	-	-	-	12.4	8.2	26.9	17.0	72.6	7.0	74.2	549.0
2001	7.7	69.7	102.5	92.0	110.1	22.6	68.8	35.3	0.0	76.0	51.3	114.7	750.7
2002	49.3	46.7	58.9	162.7	78.1	93.0	73.1	58.7	23.2	65.3	14.1	73.5	796.6
2003	40.3	75.2	113.2	152.9	53.3	79.4	78.9	55.2	31.7	121.6	86.3	48.9	936.9
2004	38.9	101.3	77.2	115.1	140.0	46.9	48.5	20.5	34.3	39.9	88.8	4.0	755.4
2005	62.2	51.9	172.4	81.9	125.3	82.0	19.1	43.6	68.7	72.2	38.1	40.5	857.9
2006	86.3	70.3	62.5	162.7	85.1	44.0	91.5	22.9	28.3	103.0	20.2	30.0	806.8
2007	50.3	58.2	77.0	192.5	75.4	74.5	89.4	38.3	0.5	65.4	123.6	31.8	876.9
2008	27.7	29.3	46.6	44.4	107.6	86.3	26.7	31.7	54.0	26.1	22.0	55.6	558.0
2009	26.0	40.6	113.4	110.8	93.1	80.3	136.1	62.4	129.5	18.6	54.5	60.7	926.0
2010	152.2	65.5	60.5	200.0	102.2	57.9	71.6	14.4	16.3	148.7	0.0	6.6	895.9
2011	58.1	103.7	76.7	182.1	120.8	29.7	54.2	27.9	19.8	52.6	45.0	17.9	788.5
2012	36.9	96.0	56.2	41.0	113.5	30.6	78.3	2.6	20.5	41.7	19.0	120.4	656.7
Average (1983-2012)	52.2	69.9	65.2	101.9	98.1	63.8	51.4	30.6	28.5	63.3	61.0	49.8	722.0

Monthly precipitation (mm)

Yeghvard

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1983	14.3	33.9	35.4	11.2	68.2	70.7	16.0	17.9	5.4	43.8	97.4	11.6	425.8
1984	6.6	45.2	79.5	79.6	31.0	10.2	15.7	7.0	0.8	51.0	10.9	13.3	350.8
1985	63.4	111.6	44.2	28.7	30.7	21.4	22.3	0.5	1.1	33.5	5.2	41.8	404.4
1986	21.2	26.5	16.6	34.7	108.6	43.8	25.9	1.4	7.7	46.2	67.9	12.8	413.3
1987	78.3	53.8	42.2	52.1	78.6	6.0	3.7	25.9	14.0	86.0	37.6	106.0	584.2
1988	62.9	28.4	39.9	42.1	109.5	75.5	18.5	37.7	13.1	47.1	22.2	46.8	543.7
1989	0.2	2.1	16.0	20.4	27.7	18.0	13.8	2.1	17.0	102.3	89.5	22.5	331.6
1990	24.0	7.0	2.8	123.0	62.6	20.8	16.6	11.1	8.3	47.6	32.7	22.5	379.0
1991	52.1	22.8	35.5	42.4	54.4	58.5	40.7	9.9	1.5	22.7	76.2	31.6	448.3
1992	37.9	77.8	32.1	26.5	61.7	81.1	15.1	17.8	30.9	5.3	56.7	41.9	484.8
1993	27.5	49.3	33.7	40.3	87.3	37.2	11.8	8.4	3.7	28.1	56.9	12.7	396.9
1994	28.0	64.8	43.1	140.2	63.8	50.7	13.6	10.3	16.8	32.8	70.6	36.4	571.1
1995	19.3	16.3	47.8	87.9	46.7	28.8	7.1	22.0	68.6	14.3	30.2	0.3	389.3
1996	37.3	31.6	40.9	92.6	46.3	18.6	58.8	1.1	15.3	32.1	0.0	62.4	437.0
1997	9.1	31.2	49.6	44.5	43.2	33.5	33.4	7.9	12.4	52.6	21.4	48.7	387.5
1998	28.3	42.8	29.1	47.4	92.5	44.5	60.9	1.8	2.9	4.4	35.8	19.2	409.6
1999	0.9	20.1	48.0	37.4	52.0	47.5	71.4	28.1	32.6	39.1	16.1	13.9	407.1
2000	51.6	24.9	14.7	42.7	75.4	15.3	16.7	6.7	7.9	43.7	4.0	42.2	345.8
2001	6.5	21.6	65.1	63.6	50.5	12.5	13.4	28.2	0.0	58.5	30.7	71.4	422.0
2002	23.0	20.0	29.0	122.0	66.0	59.0	23.0	27.0	8.0	36.0	14.0	51.0	478.0
2003	24.0	45.0	72.0	70.0	37.0	54.0	27.0	20.0	11.0	48.0	46.0	18.0	472.0
2004	25.6	21.9	33.5	42.4	66.3	32.9	34.5	11.1	15.7	32.3	26.5	3.3	346.0
*2005													488.0
*2006													496.0
*2007													495.0
*2008	-	-	-	-	-	-	-	7.1	41.4	11.2	14.5	37.3	384.0
2009	23.7	35.9	54.4	95.2	35.5	42.7	89.2	12.8	82.4	13.8	26.6	44.2	556.4
2010	74.8	48.0	41.4	139.8	98.4	16.2	48.3	1.9	3.9	92.5	0.0	3.8	569.0
2011	41.3	53.7	35.4	103.1	131.3	33.0	36.1	21.0	6.1	37.7	21.4	9.9	530.0
2012	25.0	69.5	20.3	35.2	35.8	48.6	43.8	1.1	17.6	23.7	14.2	69.0	403.8
Average (1983-2012)	31.0	38.7	38.5	64.0	63.9	37.7	29.9	12.9	16.5	40.2	34.3	33.1	445.0

(4) Monthly Discharge River Flow (Appendix D-4)

Hrazdan river – Hrazdan o.s. – Average, minimum and maximum monthly discharges of water

Water discharges, m3/sec.

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	2.04	1.97	5	15.4	18.6	13.8	4.16	3.23	2.84	2.76	4.76	2.8
1984	2.44	2.03	4.37	22.5	27.8	13.1	4.46	2.53	2.56	2.46	2.33	2
1985	2.05	2.11	3.03	22.9	16.9	5.23	2.9	2.08	2.39	2.41	2.23	2.17
1986	2.05	2.1	3.39	15.2	19.5	13.6	3.4	2.78	2.56	2.74	3.06	4.4
1987	7.21	5.69	3.18	16.2	45.8	11.5	3.11	2.69	2.65	2.85	3.33	3.18
1988	2.6	2.63	5.71	38.3	51.8	29.8	10.4	5.19	3.64	3.9	3.87	4.27
1989	3.44	3.17	5.86	12.5	5.66	3.78	3.39	3.22	3.32	4.97	5.04	7.63
1990	3.65	2.79	9.88	28.5	35.1	13.6	5.4	4.8	4.88	5.21	6.24	4.84
1991	2.86	2.96	9.14	18.7	32.4	8.15	3.72	3.03	3.64	3.52	3.96	4.01
1992	3.87	3.87	5.24	21.9	33.8	23.2	8.15	4.54	5.43	4.61	5.26	5.67
1993	5.87	6.28	7.63	27.1	46.2	21.6	5.27	5.45	4.8	5	4.56	4.47
1994	4.8	5	11.8	31.4	38.3	9.48	5.07	3.85	4.09	3.81	4.09	4.11
1995	4.38	4.26	9.06	28	28.6	12.1	4.52	3.08	3.32	2.28	3.41	2.97
1996	2.22	2.73	3.3	13.4	32.9	5.53	2.83	4.26	2.05	2.28	2.94	3.21
1997	2.5	2.59	2.77	21.3	31.2	10.5	4.55	2.72	2.99	3.17	3.74	2.76
1999	1.91	1.91	2.21	8.2	12	7.53	5.19	2.61	2.45	2.04	2.02	1.86
2000	1.93	1.98	2.55	16.4	13.4	5.77	2.19	1.94	2.17	2.48	2.43	2.36
2001	1.97	2.08	5.65	13.9	15.2	6.07	2.44	2.14	2.04	2.11	1.96	2.14
2002	2.07	2.14	3.9	13.7	30	17.1	5.45	3.95	3.46	3.24	2.57	2.11
2003	2.49	2.37	2.67	36.3	33.7	10.3	4.26	3.46	2.91	3.98	6.88	3.37
2004	2.63	2.46	14.1	17	28.6	11.8	4.7	3.46	4.74	4.11	4.17	3.53
2005	2.77	2.79	3.97	34	24.5	7.86	4.25	3.88	4.56	5.81	5.7	3.96
2006	3.58	3.47	7.7	40.6	31.3	6.74	6.1	3.64	2.98	3.22	2.89	2.59
2007	2.64	2.6	3.87	14.4	59	11.6	4.75	3.71	3.09	3.26	4.4	3.18
2008	2.92	2.68	8.79	14.1	12.7	8.31	3.93	3.46	3.62	3.26	3.22	2.98
2009	2.76	2.77	4.5	11	30.7	12.1	7.35	5.47	5.62	4.98	5.28	3.77
2010	4.12	5.06	19.5	24.1	31.9	12	5	3.57	3.49	5.17	4.33	3.84
2011	3.53	3.37	7.49	28.5	46.4	19.9	5.95	3.98	4.12	4.82	4.8	3.67
2012	3.94	3.2	3.6	17.4	13.2	7.64	6.78	4.6	3.83	3.42	3.2	3.09
average	3.15	3.07	6.2	21.5	29.2	11.71	4.82	3.56	3.46	3.58	3.89	3.48
max.	7.21	6.28	19.5	40.6	59	29.8	10.4	5.47	5.62	5.81	6.88	7.63
min.	1.91	1.91	2.21	8.2	5.66	3.78	2.19	1.94	2.04	2.04	1.96	1.86

Hrazdan river – Lusakert o.s. – Average, minimum and maximum monthly discharges of water

Water discharges, m3/sec.

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	2.64	3.19	3.20	3.28	4.33	5.49	2.67	2.33	2.51	10.20	3.25	2.52
1984	2.91	3.55	7.02	10.60	6.68	3.98	2.94	2.85	2.99	3.58	3.49	3.21
1985	3.23	3.30	3.52	5.97	4.22	3.50	3.36	3.30	2.89	3.29	3.28	2.80
1986	2.74	3.08	3.03	4.96	7.24	5.57	2.46	2.65	2.86	3.20	3.56	2.81
1987	2.83	3.04	3.55	9.87	11.90	3.06	2.62	2.63	2.74	3.62	4.22	3.46
1988	3.47	3.21	5.72	18.90	15.50	6.94	4.06	3.26	4.21	7.34	3.97	4.00
1989	3.20	3.14	3.64	3.66	3.40	3.54	3.86	3.75	3.59	3.76	6.87	4.98
1990												
1991												
1992												
1993												
1994												
1995												
1996												
1997												
1998												
1999	4.26	4.31	4.26	5.43	4.59	5.01	4.76	4.75	4.55	4.66	4.90	4.62
2000	3.76	3.75	4.28	6.27	4.82	3.01	2.52	2.71	3.22	3.18	3.00	2.71
2001	2.50	2.51	3.13	4.33	3.39	2.61	3.06	2.84	2.73	3.07	3.20	3.08
2002	2.55	2.57	3.46	7.86	9.01	5.11	3.23	3.50	3.39	3.10	3.44	2.64
2003	2.54	2.72	3.41	14.70	9.49	6.07	4.50	3.20	2.93	3.02	3.58	2.74
2004	2.61	2.77	9.70	7.48	7.98	5.41	4.98	4.36	4.40	4.32	6.08	3.76
2005	3.42	3.54	4.11	12.90	7.28	4.59	3.90	3.87	4.09	5.12	6.45	3.89
2006	2.98	3.02	4.64	13.40	9.16	4.18	3.86	3.35	3.36	3.35	3.38	3.34
2007	2.54	2.62	3.39	5.92	20.80	3.44	3.25	3.13	3.15	3.31	3.25	3.16
2008	3.03	3.18	4.19	3.95	3.13	2.65	2.76	2.98	3.03	3.02	3.07	2.56
2009	2.30	2.31	2.84	4.26	5.60	3.78	2.60	2.80	3.09	3.28	3.48	3.10
2010	3.19	3.78	7.99	9.28	8.88	4.80	3.87	3.01	2.73	3.10	2.72	2.62
2011	2.42	2.64	4.05	9.83	10.20	3.95	3.09	2.43	2.62	2.88	3.00	2.81
2012	2.64	2.75	3.01	5.77	4.67	3.46	3.39	3.02	3.07	3.22	3.06	3.15
average	2.94	3.09	4.39	8.03	7.73	4.29	3.42	3.18	3.25	3.98	3.87	3.24
max.	4.26	4.31	9.70	18.90	20.80	6.94	4.98	4.75	4.55	10.20	6.87	4.98
min.	2.30	2.31	2.84	3.28	3.13	2.61	2.46	2.33	2.51	2.88	2.72	2.52

Hrazdan river – Yerevan o.s. – Average, minimum and maximum monthly discharges of water

Water discharges, m3/sec.

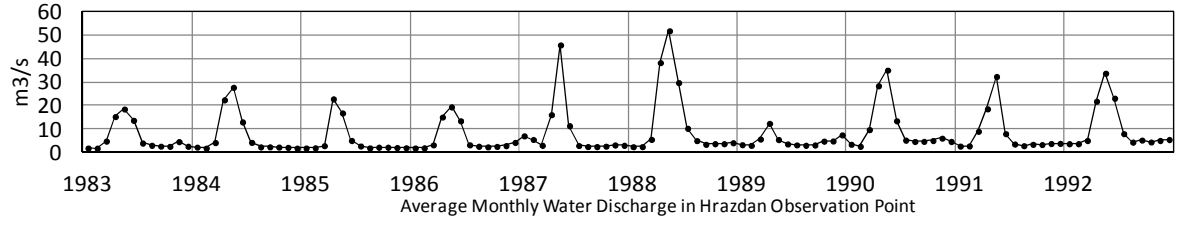
Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2001	3.91	4.36	5.68	4.6	3.28	2.54	2.36	2.33	2.23	2.48	3.28	3.73
2002	3.66	3.88	3.56	4.9	11.7	6.6	4.26	3.8	3.82	4.01	3.8	3.88
2003	4.16	4.89	5.08	28.6	19.2	3.11	2.29	3.11	3.46	5.31	5.08	4.97
2004	4.02	3.91	24.9	26.9	13.1	2.9	2.85	1.98	2.54	5.18	4.52	5.37
2005	5.54	11.5	29.7	71.9	13.1	4.87	–	–	–	–	–	–
2006	–	14.2	34.4	46.7	21.9	1.72	2.09	2.23	2.15	4.58	4.43	10.7
2007	5.57	5.96	7.8	17.7	51.8	3.34	2.26	2.72	2.41	2.24	7.24	10.8
2008	5.09	6.84	15.6	10.4	3.01	3.5	3.66	4.53	4.76	3.84	3.89	4.76
2009	6.4	10.4	11.2	11.6	9.99	7.35	7.92	5.12	1.96	1.91	4.83	8.91
2010	7.19	14.5	19.9	18.2	17.5	3.83	3.53	3.35	3.34	7.97	9.47	10.5
2011	10.5	9.78	7.18	19	15.2	6.06	3.64	3.34	2.88	2.88	3.06	11.7
2012	11.7	10.3	10.3	16.9	6.62	3.38	2.65	2.27	2.17	2.47	2.48	2.52
average	6.16	8.38	14.61	23.1	15.5	4.1	3.41	3.16	2.88	3.9	4.73	7.08
max.	11.7	14.5	34.4	71.9	51.8	7.35	7.92	5.12	4.76	7.97	9.47	11.7
min.	3.66	3.88	3.56	4.6	3.01	1.72	2.09	1.98	1.96	1.91	2.48	2.52

Kasakh river – Ashtarak o.s. – Average, minimum and maximum monthly discharges of water

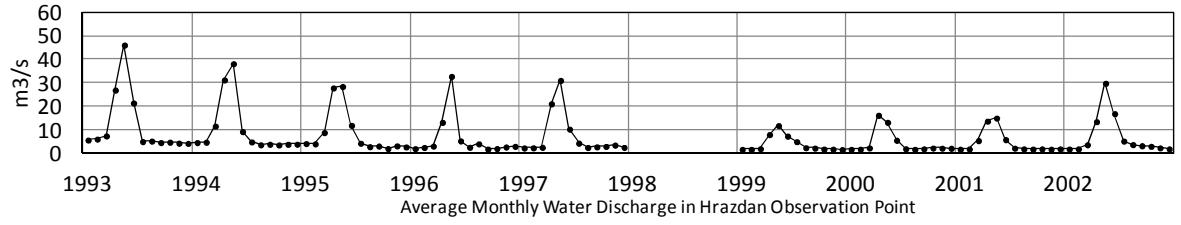
Water discharges, m3/sec.

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1983	2.48	2.44	3.29	5.24	2.76	2.88	2.71	2.63	2.47	1.92	2.45	2.03
1984	1.94	2.12	9.9	4.8	2.44	2.59	2.77	3.36	2.92	2.07	2.37	2.73
1985	2.94	2.88	3.15	12.5	2.41	2.44	2.87	3.1	2.74	2.64	2.68	3.27
1986	3.32	3.35	3.76	3.57	3.43	2.86	2.42	2.43	2.41	2.86	3.02	3.33
1987	3.59	3.16	2.6	6.6	2.64	2.53	2.37	2.31	2.3	2.56	3.18	3.25
1988	3.04	3.03	3.54	17.8	4.38	2.67	2.22	2.22	2.54	2.63	3.34	3.15
1989	2.88	2.39	2.96	1.7	1.3	1.38	1.44	1.41	1.44	1.69	2.44	2.42
1990	2.02	2.1	3.23	3.04	1.62	1.07	1.1	1.16	1.42	2.44	2.49	2.45
1991	1.93	1.86	7.65	8.11	–	1.48	1.53	1.44	1.59	1.98	2.89	2.05
1992	2.35	2.2	2.12	10.2	2.27	2.13	2.01	2.05	2.17	2.17	2.23	2.27
1993	2.17	2.28	2.25	8.49	3.4	2.59	2.24	2.36	2.23	3.4	3.78	2.63
1994	2.68	2.53	2.64	6.53	2.81	3.18	2.34	2.3	2.46	2.55	2.61	2.65
1995	2.52	2.48	3.55	6.69	3.19	2.36	2.3	2.48	2.86	2.55	2.4	2.22
1996	2.21	2.25	3.4	10.9	4.81	2.27	2.4	2.55	2.61	2.42	2.38	2.35
1997	3.04	2.84	2.98	8.36	3.04	2.55	2.78	2.5	2.6	2.81	3.22	2.89
1998	2.54	2.46	3.25	3.73	2.93	2.4	2.48	2.47	2.37	2.4	2.49	2.53
1999	2.56	2.65	2.72	3	2.26	2.54	2.28	2.76	2.22	2.16	2.58	2.78
2000	2.55	2.6	2.63	5.38	1.92	2.12	2.49	2.73	2.59	2.56	2.48	2.79
2001	2.67	2.77	3.5	3.12	1.7	1.63	1.97	2.2	1.45	1.78	2.02	2.31
2002	1.71	1.85	3.59	10.5	1.94	2.03	2.09	2.16	1.97	2.07	1.88	2.57
2003	2.93	2.88	2.81	13	3.67	2.6	2.3	1.9	1.9	2.08	5.57	2.24
2004	2.13	2.25	7.33	4.6	5.53	3.47	3.42	3.14	2.58	3.16	3.16	2.45
2005	2.54	2.99	3.51	7.54	3.05	2.84	2.6	2.4	2.59	2.58	2.91	2.9
2006	3.15	3.21	4.56	7.38	4.16	5.19	2.46	2.67	2.31	3.27	3.39	3.09
2007	2.82	3.04	3.3	5.45	5.13	3.96	2.85	2.58	2.63	2.63	2.96	3.1
2008	2.8	2.7	3.68	2.95	2.78	2.39	2.61	2.4	2.48	2.65	2.8	2.85
2009	2.85	2.81	3.27	4.65	3.29	2.69	2.7	2.82	2.72	2.87	3.12	2.93
2010	2.94	3.18	6.62	6.3	4.58	2.63	2.56	2.74	2.69	3.11	3.04	2.61
2011	2.39	2.58	3.43	7.15	3.72	3	2.65	2.89	3.78	3.28	3.07	2.61
2012	2.53	2.44	2.78	6.51	2.94	2.57	2.52	2.43	2.77	2.99	3.02	2.61
average	2.61	2.61	3.8	6.86	3.11	2.57	2.38	2.42	2.39	2.54	2.87	2.67
max.	3.59	3.35	9.9	17.8	5.53	5.19	3.42	3.36	3.78	3.4	5.57	3.33
min.	1.71	1.85	2.12	1.7	1.3	1.07	1.1	1.16	1.42	1.69	1.88	2.03

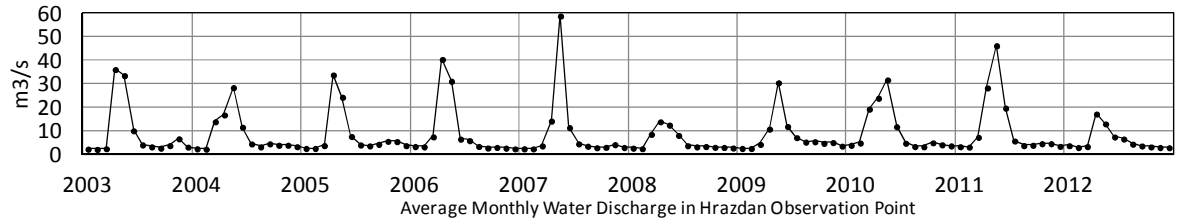
Hrazdan Observation Point



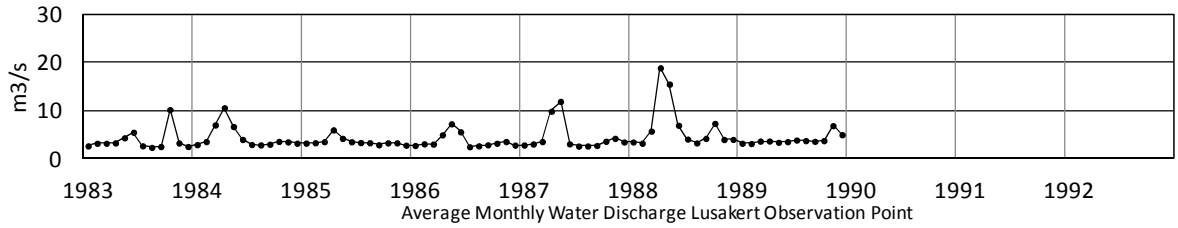
Average Monthly Water Discharge in Hrazdan Observation Point

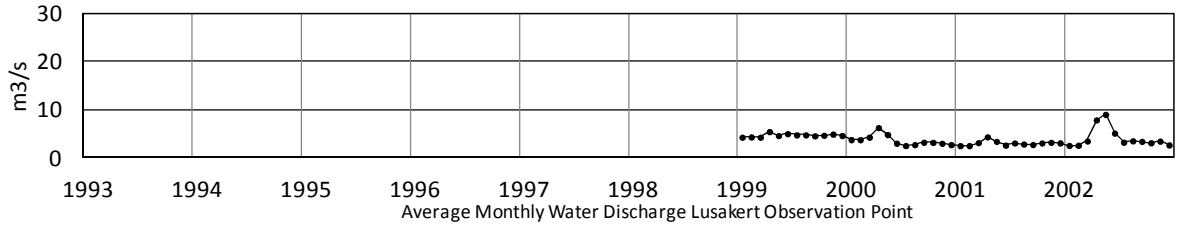


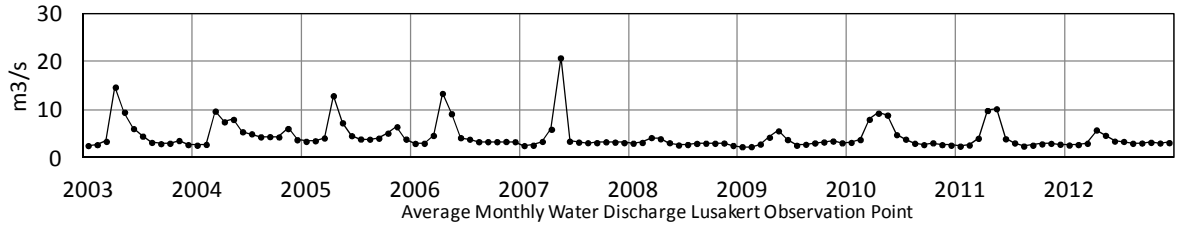
Average Monthly Water Discharge in Hrazdan Observation Point



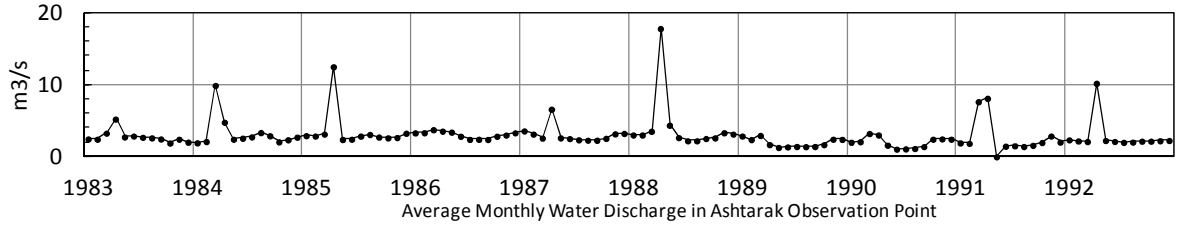
Lusakert Observation Point

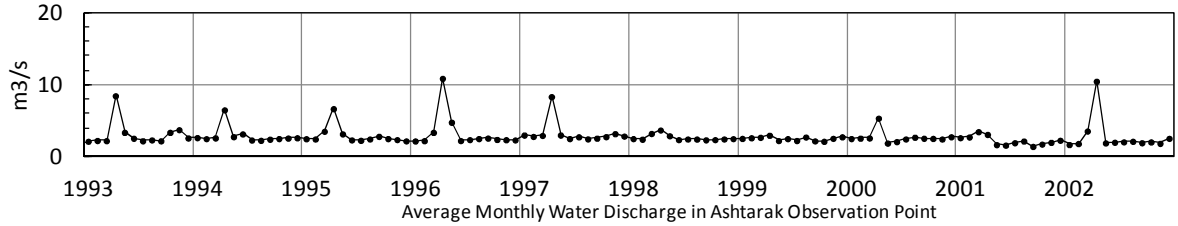


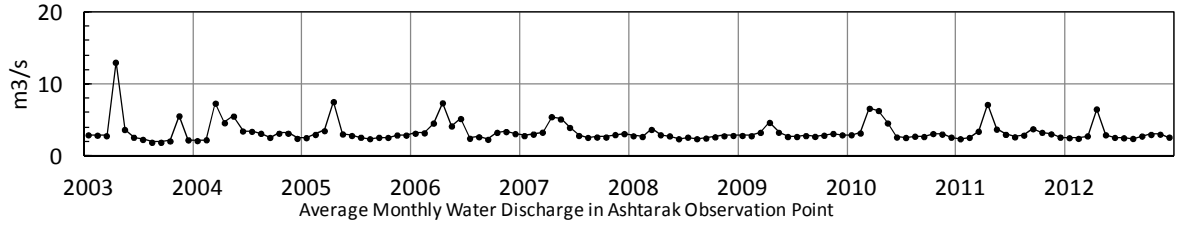




Ashtarak Observation Point







(5) 10 days Discharge Flow (Appendix D-5)

Mean, maximal, minimal decade discharges of Hrazdan river–Lusakert station (cubic meter per second), for 2003-2012

Year	Decade	Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2003	1	2.43	2.71	3.02	12	13.4	6.55	5.27	3.31	3.08	3.07	3.29	2.75
	2	2.61	2.64	3.39	15.6	9.16	5.79	4.26	3.04	2.89	2.86	4.49	2.79
	3	2.59	2.84	3.79	16.5	6.19	5.88	4.02	3.23	2.82	3.13	2.97	2.68
	max	2.82	2.96	4.44	43.7	17.1	6.92	7.24	6.6	3.28	4.88	19.1	2.96
	min	2.4	2.54	2.82	3.64	5.4	5.4	3.64	2.68	2.82	2.68	2.82	2.54
2004	1	2.52	2.74	16.1	6.08	9.36	6.22	5.2	4.42	4.43	4.34	8.64	3.82
	2	2.6	2.79	5.85	7.7	7.72	5.25	5	4.36	4.43	4.3	5.62	3.71
	3	2.7	2.78	7.36	8.68	6.95	4.75	4.75	4.3	4.35	4.31	3.98	3.75
	max	4	3.5	155	15	12.5	6.75	8.25	4.5	4.5	4.4	11	3.9
	min	2.5	2.62	2.88	5.5	4.5	4.5	4.4	4.2	4.2	4.2	3.9	3.7
2005	1	3.44	3.47	4.29	5.98	9.21	4.96	4.1	3.71	4.18	4.2	11.5	3.85
	2	3.46	3.46	3.85	13.2	7.1	4.44	3.82	3.96	4.04	4.23	4.02	3.85
	3	3.37	3.75	4.18	19.6	5.7	4.39	3.81	3.94	4.06	6.76	3.85	3.97
	max	3.52	4.01	8	40.5	14.5	5.9	4.34	4.18	4.34	9.33	16.4	4.01
	min	3.2	3.36	3.52	4.9	5.1	4.34	3.69	3.69	4.01	4.18	3.85	3.85
2006	1	3.03	2.91	3.44	11.14	13.4	4.43	4.48	3.36	3.21	3.31	3.48	3.26
	2	2.99	3.09	4.33	12.54	8.38	3.93	3.68	3.38	3.42	3.36	3.39	3.37
	3	2.91	3.06	6.14	16.59	5.69	4.18	3.42	3.31	3.44	3.39	3.26	3.38
	max	3.03	3.15	14.1	35.1	19.7	5.25	5.25	3.5	4	4	3.75	3.5
	min	2.91	2.91	3.15	6.6	5.25	3.75	3.26	3.26	2.91	3.15	3.26	3.15
2007	1	2.53	2.56	3.14	3.66	33.3	3.76	3.2	3.13	3.22	3.23	3.33	3.11
	2	2.52	2.61	3.15	5.43	25.9	3.38	3.31	3.14	3.1	3.37	3.3	3.15
	3	2.57	2.7	3.83	8.67	4.83	3.19	3.25	3.13	3.11	3.33	3.14	3.21
	max	2.6	2.84	9	33	74	4.14	3.82	3.45	3.33	3.45	3.58	3.21
	min	2.52	2.48	2.72	3.21	4.14	2.97	3.09	3.09	3.09	3.21	3.09	3.09
2008	1	3.12	3.15	3.56	4.21	3.41	2.65	2.69	2.9	3.09	2.96	3.12	2.76
	2	2.96	3.17	4.73	3.94	3.14	2.64	2.75	2.98	3.03	3.02	3.13	2.57
	3	3.02	3.21	4.27	3.68	2.87	2.67	2.83	3.05	2.97	3.06	2.96	2.37
	max	3.25	3.25	10.7	4.34	3.53	2.72	2.86	3.09	3.11	3.09	3.16	2.85
	min	2.92	3.14	3.25	3.56	2.74	2.62	2.68	2.87	2.94	2.94	2.87	2.29
2009	1	2.3	2.32	2.51	3.72	6.86	4.2	2.91	2.45	3.02	3.25	3.61	3.2
	2	2.3	2.3	3.13	4.12	5.27	3.7	2.54	2.92	3.08	3.28	3.48	3.08
	3	2.31	2.3	2.88	4.93	4.7	3.46	2.39	3	3.17	3.31	3.34	3.03
	max	2.42	2.42	6.52	6.52	9.1	4.41	3.22	3.01	3.21	3.21	3.6	3.26
	min	2.3	2.3	2.3	2.99	4.2	3.22	2.26	2.15	3.01	3.54	3.28	3.03
2010	1	3.05	3	5.37	7.04	10.8	5.2	3.8	3.57	2.62	3.44	2.79	2.61
	2	3.35	3.67	12.2	9.44	9.57	4.89	3.76	2.79	2.73	2.98	2.69	2.67
	3	3.16	4.89	6.53	11.36	6.53	4.33	4.03	2.71	2.83	2.9	2.69	2.57
	max	3.88	6.85	17.3	20.3	13.3	5.72	4.82	3.92	2.9	4.26	2.8	2.69
	min	3	3	3.71	5.72	5.72	4.06	3.53	2.44	2.58	2.8	2.69	2.48
2011	1	2.47	2.54	2.91	10.5	17.2	4.58	3.05	2.42	2.51	2.78	3.05	2.8
	2	2.4	2.6	3.5	8.5	7.75	3.96	2.98	2.26	2.56	2.85	3.02	2.89
	3	2.4	2.83	5.6	10.5	6.15	3.31	2.94	2.6	2.8	2.99	2.92	2.76
	max	2.58	2.94	7.78	20.2	25.4	5.07	3.31	2.76	3.68	3.13	3.13	2.94
	min	2.4	2.4	2.76	5.07	5.07	3.13	2.76	2.04	2.4	2.76	2.76	2.76
2012	1	2.67	2.68	2.81	5.1	5.4	3.65	3.31	3.2	2.92	3.3	3.01	3.12
	2	2.59	2.8	2.96	7.1	4.65	3.41	3.3	3.08	3.05	3.25	3.1	3.14
	3	2.67	2.78	3.23	5.13	4.02	3.32	3.24	2.79	3.24	3.12	3.06	3.17
	max	2.76	2.8	3.6	11.3	6.3	3.7	3.32	3.28	3.28	3.37	3.2	3.2
	min	2.58	2.67	2.7	3.4	3.86	3.3	3.2	2.75	2.8	3.04	2.96	3.04

Mean, maximal, minimal decade discharges of Hrazdan river–Hrazdan station (cubic meter per second), for 2003-2012

Year	Decade	Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2003	1	2.58	2.6	2.48	28.9	41	15.8	4.68	4.1	2.93	3.64	5.3	4.05
	2	2.42	2.34	2.95	38.1	38.6	8.34	3.2	2.74	2.93	3.21	10.5	3.41
	3	2.48	2.13	2.57	42	22.4	6.71	4.84	3.52	2.86	4.98	4.86	2.71
	max	2.9	2.78	3.55	87	58.8	21.4	12.7	7	4.9	13.8	19.5	4.5
	min	2	1.81	1.81	2.2	14.2	4.5	2.4	2.2	2	2.53	4.13	2.3
2004	1	2.98	2.35	22.2	8.65	39.8	17.9	5.59	3.6	5.85	4.08	4.49	3.52
	2	2.51	2.44	6.61	20.9	26.4	10.1	3.89	3.25	4.58	4.15	4.24	3.49
	3	2.42	2.62	13.5	21.4	20.4	7.37	4.63	3.52	3.8	4.1	3.78	3.57
	max	3.36	3.36	138	54.3	54.3	24	10.9	5.58	24	5.58	5.75	3.95
	min	1.64	1.78	2.89	5.58	16.3	5.23	2.63	2.51	3.05	3.52	3.52	3.05
2005	1	2.79	2.73	4.44	7.75	30.4	11	5.2	3.53	5.09	6.03	7.35	4.49
	2	2.76	2.72	3.54	36.2	28.4	7.72	3.83	3.95	4.11	5.66	5.12	3.79
	3	2.78	2.94	3.92	58.1	15.6	4.89	3.76	4.12	4.49	5.76	4.62	3.63
	max	2.9	3.54	10.5	90.1	38.7	17.1	8.34	6.41	6.89	10.8	8.92	4.85
	min	2.63	2.52	2.8	4.5	9.82	3	3.1	2.9	3.78	4.2	4.05	3.2
2006	1	3.79	3.55	3.87	23.5	48.9	9.91	10.1	3.89	3.05	3.02	2.99	2.61
	2	3.57	3.49	6.76	45.6	30.6	5.43	4.57	3.51	2.98	3.48	2.98	2.59
	3	3.41	3.37	12	52.6	15.9	4.89	3.84	3.53	2.91	3.17	2.7	2.56
	max	4.15	3.72	19.1	97.2	59.9	15.2	21.8	5.76	5.52	5.76	5.27	2.68
	min	3.26	3.17	3.47	17.1	12.4	3.72	3.47	2.88	2.58	2.58	2.58	2.5
2007	1	2.69	2.62	2.93	5.68	72.5	14.6	5.07	3.81	3.36	2.88	4.63	3.35
	2	2.6	2.6	3.17	11.9	79.3	10.5	5.57	3.63	2.99	3.39	4.92	3.32
	3	2.63	2.57	5.37	25.7	28.3	9.73	3.73	3.68	2.93	3.5	3.65	2.91
	max	2.81	2.68	9.22	89	128	20.3	11.6	12.4	4.44	4.09	8.16	3.63
	min	2.29	2.29	2.42	2.81	18.9	5.6	2.62	2.74	2.74	2.62	3.08	2.62
2008	1	2.92	2.59	3.85	12	10.2	7.54	5.48	3.4	3.32	3.14	3.18	3.17
	2	2.88	2.75	7.08	15.8	14.3	8.01	3.44	3.46	3.94	3	3.15	2.9
	3	2.96	2.69	14.9	14.5	13.6	9.38	2.97	3.51	3.59	3.61	3.32	2.89
	max	3.02	3.02	19.2	25.3	20.1	13.3	8.09	4.89	5.35	4.02	3.84	3.66
	min	2.75	2.4	2.61	8.96	8.09	5.83	2.61	2.75	2.89	2.75	2.61	2.61
2009	1	2.8	2.69	3.65	10.6	33.4	14.6	8	6.74	3.81	6.11	8.17	3.79
	2	2.78	2.93	5.29	8.91	29.2	11.5	7.77	5.27	4.98	4.71	4.15	3.53
	3	2.71	2.67	4.55	13.6	29.5	10.3	6.39	4.49	8.08	4.21	3.53	3.96
	max	3.1	3.43	11.9	32.8	50.3	19.3	17.1	6.94	10.7	7.15	9.92	5.1
	min	2.39	2.28	2.16	5.8	18.6	6.25	3.6	3.38	3.38	3.56	2.84	3
2010	1	4.51	3.45	7.78	13.1	31.6	19.1	5.42	3.46	3.33	5.58	4.79	4.09
	2	3.87	5.29	38.4	22.1	39.3	9.74	4.67	3.69	3.52	4.85	4.37	3.98
	3	3.98	6.79	12.8	37.2	25.5	7.27	4.93	3.56	3.61	5.09	4.07	3.5
	max	6.08	8.87	60.5	60.5	46.7	22.4	11.1	4.9	4.28	9.13	5.82	4.28
	min	3.06	2.9	4.02	8.87	22.8	6.07	3	3.11	3	3.42	3.75	3.27
2011	1	3.46	3.18	3.74	19.9	70.7	29.3	7.31	3.45	3.98	4.5	5.27	3.69
	2	3.56	3.44	6.65	24.5	36.8	18.2	6.02	3.95	4.07	4.94	4.86	3.71
	3	3.56	3.52	11.7	41.2	33.2	12.1	4.59	4.5	4.3	5.02	4.25	3.61
	max	3.83	3.62	17	61.9	99	44.9	9.49	6.77	5.62	6.19	5.91	3.91
	min	3.23	2.97	3.23	16.6	23.6	9.97	3.17	2.76	3.54	3.17	3.73	3.36
2012	1	3.9	3.33	2.84	10.9	15.5	8.58	7.43	5.71	3.85	3.49	3.18	3.19
	2	4.03	3.05	2.75	25.4	14	7.2	7.2	4.31	3.84	3.46	3.13	3.11
	3	3.9	3.24	5.05	16	10.4	7.12	5.8	3.86	3.81	3.34	3.28	2.98
	max	4.25	3.74	7.28	31.6	16.2	9.68	7.83	6.66	3.85	3.84	3.41	3.33
	min	3.49	2.68	2.3	3.49	9.56	7.09	5.2	3.85	3.63	3.24	2.93	2.87

Mean, maximal, minimal decade discharges of Hrazdan river–Yerevan station (cubic meter per second), for 2003-2012

Year	Decade	Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2003	1	3.38	5	5	9.58	39.8	3.2	2.6	3.02	3.11	5.23	4.91	4.83
	2	4.44	4.82	4.86	35	17	3.11	2.1	3.1	3.2	6.02	5.53	5.49
	3	4.61	4.84	5.35	41.3	3.32	3.02	2.2	3.23	4.12	4.75	4.79	4.63
	max	6.1	5.9	6.1	70	60	3.35	3.35	3.5	7.1	7.5	7.1	7.5
	min	2.6	3.9	4.15	4.45	2.6	2.6	1.9	2.6	2.75	4.15	3.9	3.8
2004	1	4.05	3.98	35.6	27.5	20	4.53	4.22	1.95	2.04	5.52	4.38	5.62
	2	4.05	3.9	16.3	35.8	14.6	2.21	2.45	2.11	2.3	5.3	4.68	5.14
	3	3.98	3.86	23	17.3	5.34	1.95	1.97	1.88	3.08	4.77	4.48	5.36
	max	4.9	11.7	174	107	36	5.3	5.1	3	4.25	6.1	6.1	12
	min	3.5	3.25	4.25	5.1	2.5	1.5	1.62	1.5	1.75	1.75	1.88	3.25
2005	1	5.62	11.4	24.7	55.1	28.2	4.33	–	–	–	–	–	–
	2	5.97	11.7	32.3	76.7	7.8	4.88	–	–	–	–	–	–
	3	5.07	11.4	31.7	83.9	4.06	5.4	–	–	–	–	–	–
	max	11.6	19.8	68.6	138	59	7.58	–	–	–	–	–	–
	min	3.17	4.5	4.5	12.2	2.5	2.83	–	–	–	–	–	–
2006	1	–	6.94	30.2	42.2	33.1	1.87	2	3.2	1.7	2.62	4.71	10
	2	–	15.9	30.5	47	29.3	1.26	2.24	1.89	2.59	5.75	4.16	8.8
	3	10.9	21.2	41.7	51	4.96	2.03	2.03	1.66	2.15	5.32	4.41	12.9
	max	–	42	67.5	81	59	3.68	4.24	4.24	4.8	20.8	8.4	24
	min	–	5.44	8	22	1	1	1	1.25	1.38	1.88	1.75	2.56
2007	1	5.82	5.46	8.46	7.56	57.6	5.44	2.24	2.55	2.56	2.29	3.47	12.6
	2	5.52	5.93	7.83	17.4	77.8	2.34	2.29	2.61	2.4	2.3	10.8	12.3
	3	5.38	6.64	7.17	28.1	22.8	2.25	2.25	2.98	2.27	2.15	7.5	7.96
	max	6.95	9.58	17.6	57.8	90.5	13	2.75	5.35	3.25	4.75	45	46
	min	4.75	5	5	4.12	6.05	2.05	2.05	2.4	2	1.85	2.1	5.35
2008	1	5.06	5.64	12.18	20.65	2.7	3.78	3.49	4.55	4.7	3.5	3.57	5.13
	2	4.11	5.91	14.12	8.15	3.01	3.33	3.57	4.61	4.6	4.65	2.97	4.53
	3	6	9.18	19.9	2.48	3.3	3.39	3.9	4.43	4.99	3.41	5.13	4.63
	max	8.5	13.9	28	23.2	9.7	5.54	5.35	6.74	8.98	10.2	9.7	14.6
	min	2.8	2.8	5.92	1.77	1.88	2.6	2.4	2.9	3	2.6	2.6	3
2009	1	4.72	8.16	13	19.1	14.2	7.67	6.23	7.49	1.73	1.82	7	11.3
	2	6.64	11.1	11.2	8.02	8.55	8.41	9.25	5.15	1.74	1.94	2.18	9.6
	3	7.71	12.4	9.65	7.56	7.52	5.96	8.26	2.93	2.41	1.95	5.31	6.16
	max	11.4	21.9	23.3	28	22.6	13.9	13.9	14.6	11.2	2.18	23.1	13.9
	min	3.99	4.45	3.37	3.21	3.37	3.52	3.21	2.18	1.38	1.3	1.77	2.36
2010	1	6.45	11.9	16	17	21.3	4.45	3.57	3.4	3.77	6.39	8.95	11.3
	2	7.02	12.7	24.1	16.8	20.7	4	3.43	3.21	3.06	7.96	9.91	10.7
	3	8.02	20	19.7	20.8	11.2	3.04	3.6	3.44	3.19	9.43	9.55	9.7
	max	21.5	23.2	29.8	27.5	29.1	9.69	4.8	7.9	4.8	16	16.3	19.3
	min	2.13	2.53	6.79	8.13	3.16	2.21	2.53	2.37	2.53	2.85	4.1	4.41
2011	1	12.7	10.9	7.83	18.9	26.5	8.8	3.07	3.84	3.14	2.89	2.95	10.7
	2	8.88	9.1	5.85	19.3	13.8	6.49	4.69	3.07	2.78	2.78	3.06	11.4
	3	9.87	9.29	7.81	19	6.27	2.89	3.21	3.14	2.73	2.95	3.17	12.8
	max	18	16.4	17.2	26.4	39.3	21.2	13.4	11.5	3.96	3.8	4.11	20.5
	min	4.43	4.43	2.85	5.55	4.43	2.63	2.7	2.7	2.18	2.55	2.55	5.18
2012	1	11.4	10.7	9.8	17.29	6.53	4.81	2.74	2.22	2.14	2.3	2.44	2.57
	2	12.1	10.2	10.3	26.99	7.24	2.76	2.81	2.45	2.14	2.73	2.5	2.5
	3	11.7	9.9	10.64	6.29	6.15	2.58	2.44	2.16	2.24	2.38	2.5	2.5
	max	21.1	21.1	17.9	42.1	8.5	7.59	5.41	2.45	2.36	2.55	2.55	2.98
	min	6.6	8.48	8.1	4.6	2.85	2	2.19	2.1	2.1	2.1	2.36	2.45

Mean, maximal, minimal decade discharges of Kasakh river–Ashtarak station (cubic meter per second), for 2003-2012

Year	Decade	Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2003	1	2.96	2.92	2.78	13.30	3.50	2.38	2.65	1.94	1.87	1.94	4.03	2.30
	2	2.92	2.90	2.85	13.70	3.60	2.61	2.36	1.86	1.98	2.18	10.4	2.15
	3	2.92	2.79	2.82	12.00	3.88	2.82	1.91	1.91	1.84	2.13	2.27	2.27
	max	3.21	3.00	3.07	83.8	8.48	3.21	2.79	2.30	2.10	2.37	30.5	2.44
	min	2.79	2.65	2.51	2.93	2.86	2.10	1.80	1.80	1.80	1.80	2.00	2.10
2004	1	2.20	2.24	12.40	3.18	6.05	3.35	3.36	3.55	2.69	2.97	2.96	2.65
	2	2.02	2.28	4.81	4.32	4.90	3.80	3.31	3.51	2.54	3.21	3.21	2.55
	3	2.21	2.22	5.03	6.29	5.63	3.27	3.58	2.44	2.50	3.28	3.33	2.18
	max	2.54	2.38	130	20.50	11.00	4.62	3.93	3.93	3.36	3.93	3.93	3.36
	min	1.95	2.12	2.38	1.95	2.80	2.80	2.80	2.29	2.29	2.80	2.80	1.95
2005	1	2.62	2.70	3.81	5.39	3.95	3.07	2.68	2.41	2.67	2.50	2.84	2.90
	2	2.43	2.80	3.74	12.00	2.50	2.82	2.69	2.45	2.57	2.56	2.85	2.87
	3	2.57	3.59	3.04	5.24	2.74	2.63	2.45	2.36	2.53	2.67	3.03	2.92
	max	3.31	3.82	7.80	26.30	8.61	3.82	2.90	2.64	2.80	3.21	3.21	3.11
	min	2.40	2.40	2.48	3.31	2.24	2.48	2.32	2.08	2.32	2.32	2.64	2.72
2006	1	3.14	3.23	3.5	11.4	5.81	6.46	3.16	2.63	2.94	2.9	3.4	3.32
	2	3.13	3.07	3.52	4.53	3.85	5.47	2.2	2.61	1.96	3.41	3.41	3.09
	3	3.16	3.34	6.47	6.2	2.93	3.65	2.05	2.75	2.02	3.46	3.36	2.87
	max	3.36	3.54	29.1	32.5	12.8	7.86	7.23	3	3	3.72	3.54	3.54
	min	3	3	3.36	3.72	1.7	3	1.7	2.19	1.7	2.68	3.18	2.68
2007	1	2.74	3.04	2.8	4.13	8.14	3	2.92	2.54	2.8	2.48	3	3
	2	2.8	3.29	2.82	6.45	4.59	4.28	2.96	2.47	2.77	2.64	2.97	3.14
	3	2.91	2.73	4.18	5.76	2.87	4.6	2.68	2.72	2.32	2.75	2.97	3.14
	max	2.97	3.48	17.1	20.2	16.3	5.82	3.31	2.97	3.14	2.97	3.14	3.14
	min	2.5	2.65	2.65	2.8	2.35	2.8	2.35	2.2	2.2	2.35	2.8	2.97
2008	1	3.01	2.7	3.19	3.07	2.84	2.43	2.69	2.46	2.52	2.56	2.66	2.82
	2	2.7	2.7	3.62	3.07	3.01	2.34	2.69	2.44	2.51	2.7	2.84	2.84
	3	2.7	2.7	4.19	2.72	2.53	2.39	2.47	2.32	2.41	2.7	2.9	2.9
	max	3.09	2.9	16	3.28	3.09	2.56	2.7	2.7	2.7	2.7	2.9	3.09
	min	2.7	2.7	2.7	2.7	2.42	2.29	2.42	2.15	2.15	2.42	2.42	2.7
2009	1	2.88	2.8	2.83	4.66	4.09	2.66	2.83	2.87	2.74	2.9	3.07	2.88
	2	2.81	2.8	2.88	4.65	3.11	2.71	2.58	2.86	2.63	2.72	3.01	2.9
	3	2.85	2.84	4.01	4.65	2.73	2.7	2.7	2.74	2.8	2.97	3.28	3
	max	3.08	2.94	11.4	20	6.3	2.94	3.22	3.08	3.22	3.22	4.2	3.36
	min	2.8	2.7	2.8	3.08	2.6	2.6	2.5	2.6	2.4	2.6	2.8	2.8
2010	1	2.91	2.81	4.81	5.58	6.38	2.8	2.58	2.64	2.46	3.1	2.93	2.71
	2	3	3.1	12.4	5.62	4.58	2.55	2.52	2.66	2.57	3.12	3.08	2.59
	3	2.91	3.73	3.06	7.7	2.94	2.55	2.56	2.91	3.04	3.11	3.1	2.53
	max	3.27	5.14	58.4	23.7	16.7	3.08	2.7	3.27	3.46	3.46	3.27	3.08
	min	2.7	2.7	2.7	2.7	2.7	2.47	2.36	2.47	2.24	2.89	2.89	2.47
2011	1	2.36	2.5	2.76	11.38	5.71	2.76	3.06	2.36	3.98	3.2	3.22	3.1
	2	2.38	2.55	2.76	6.38	2.98	2.58	2.58	2.61	3.86	3.26	3.08	2.78
	3	2.44	2.72	4.65	3.68	2.57	3.64	2.33	3.63	3.5	3.37	2.9	2.7
	max	2.9	2.9	20.7	44.6	17.7	4.7	3.1	4.7	4.5	3.9	3.3	3.1
	min	2.19	2.36	2.7	2.9	2.02	1.85	2.19	1.85	3.3	3.1	2.9	2.7
2012	1	2.6	2.4	2.49	5.6	3.32	2.65	2.66	2.43	2.51	2.8	2.98	2.78
	2	2.52	2.38	2.76	9.61	2.73	2.56	2.46	2.37	2.86	3.12	3.08	2.6
	3	2.46	2.54	3.05	4.32	2.79	2.49	2.44	2.47	2.94	3.05	3	2.59
	max	2.6	2.6	3.6	42.2	7.57	2.8	2.8	2.6	3	3.4	3.2	2.8
	min	2.4	2.3	2.4	3.2	2.4	2.4	2.3	2.3	2.3	2.8	2.8	2.5

Mean, maximal, minimal decade discharges of Hrazdan river–Hrazdan station + Lusakert station (cubic meter per second), for 2003–2012

Year	Decade	Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2003	1	5.01	5.31	5.5	40.9	54.4	22.35	9.95	7.41	6.01	6.71	8.59	6.8
	2	5.03	4.98	6.34	53.7	47.76	14.13	7.46	5.78	5.82	6.07	14.99	6.2
	3	5.07	4.97	6.36	58.5	28.59	12.59	8.86	6.75	5.68	8.11	7.83	5.39
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2004	1	5.5	5.09	38.3	14.73	49.16	24.12	10.79	8.02	10.28	8.42	13.13	7.34
	2	5.11	5.23	12.46	28.6	34.12	15.35	8.89	7.61	9.01	8.45	9.86	7.2
	3	5.12	5.4	20.86	30.08	27.35	12.12	9.38	7.82	8.15	8.41	7.76	7.32
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2005	1	6.23	6.2	8.73	13.73	39.61	15.96	9.3	7.24	9.27	10.23	18.85	8.34
	2	6.22	6.18	7.39	49.4	35.5	12.16	7.65	7.91	8.15	9.89	9.14	7.64
	3	6.15	6.69	8.1	77.7	21.3	9.28	7.57	8.06	8.55	12.52	8.47	7.6
	max	6.42	7.55	18.5	130.6	53.2	23	12.68	10.59	11.23	20.13	25.32	8.86
	min	5.83	5.88	6.32	9.4	14.92	7.34	6.79	6.59	7.79	8.38	7.9	7.05
2006	1	6.82	6.46	7.31	34.64	62.3	14.34	14.58	7.25	6.26	6.33	6.47	5.87
	2	6.56	6.58	11.09	58.14	38.98	9.36	8.25	6.89	6.4	6.84	6.37	5.96
	3	6.32	6.43	18.14	69.19	21.59	9.07	7.26	6.84	6.35	6.56	5.96	5.94
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2007	1	5.22	5.18	6.07	9.34	105.8	18.36	8.27	6.94	6.58	6.11	7.96	6.46
	2	5.12	5.21	6.32	17.33	105.2	13.88	8.88	6.77	6.09	6.76	8.22	6.47
	3	5.2	5.27	9.2	34.37	33.13	12.92	6.98	6.81	6.04	6.83	6.79	6.12
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2008	1	6.04	5.74	7.41	16.21	13.61	10.19	8.17	6.3	6.41	6.1	6.3	5.93
	2	5.84	5.92	11.81	19.74	17.44	10.65	6.19	6.44	6.97	6.02	6.28	5.47
	3	5.98	5.9	19.17	18.18	16.47	12.05	5.8	6.56	6.56	6.67	6.28	5.26
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2009	1	5.1	5.01	6.16	14.32	40.26	18.8	10.91	9.19	6.83	9.36	11.78	6.99
	2	5.08	5.23	8.42	13.03	34.47	15.2	10.31	8.19	8.06	7.99	7.63	6.61
	3	5.02	4.97	7.43	18.53	34.2	13.76	8.78	7.49	11.25	7.52	6.87	6.99
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2010	1	7.56	6.45	13.15	20.14	42.4	24.3	9.22	7.03	5.95	9.02	7.58	6.7
	2	7.22	8.96	50.6	31.54	48.87	14.63	8.43	6.48	6.25	7.83	7.06	6.65
	3	7.14	11.68	19.33	48.56	32.03	11.6	8.96	6.27	6.44	7.99	6.76	6.07
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2011	1	5.93	5.72	6.65	30.4	87.9	33.88	10.36	5.87	6.49	7.28	8.32	6.49
	2	5.96	6.04	10.15	33	44.55	22.16	9	6.21	6.63	7.79	7.88	6.6
	3	5.96	6.35	17.3	51.7	39.35	15.41	7.53	7.1	7.1	8.01	7.17	6.37
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–
2012	1	6.57	6.01	5.65	16	20.9	12.23	10.74	8.91	6.77	6.79	6.19	6.31
	2	6.62	5.85	5.71	32.5	18.65	10.61	10.5	7.39	6.89	6.71	6.23	6.25
	3	6.57	6.02	8.28	21.13	14.42	10.44	9.04	6.65	7.05	6.46	6.34	6.15
	max	–	–	–	–	–	–	–	–	–	–	–	–
	min	–	–	–	–	–	–	–	–	–	–	–	–

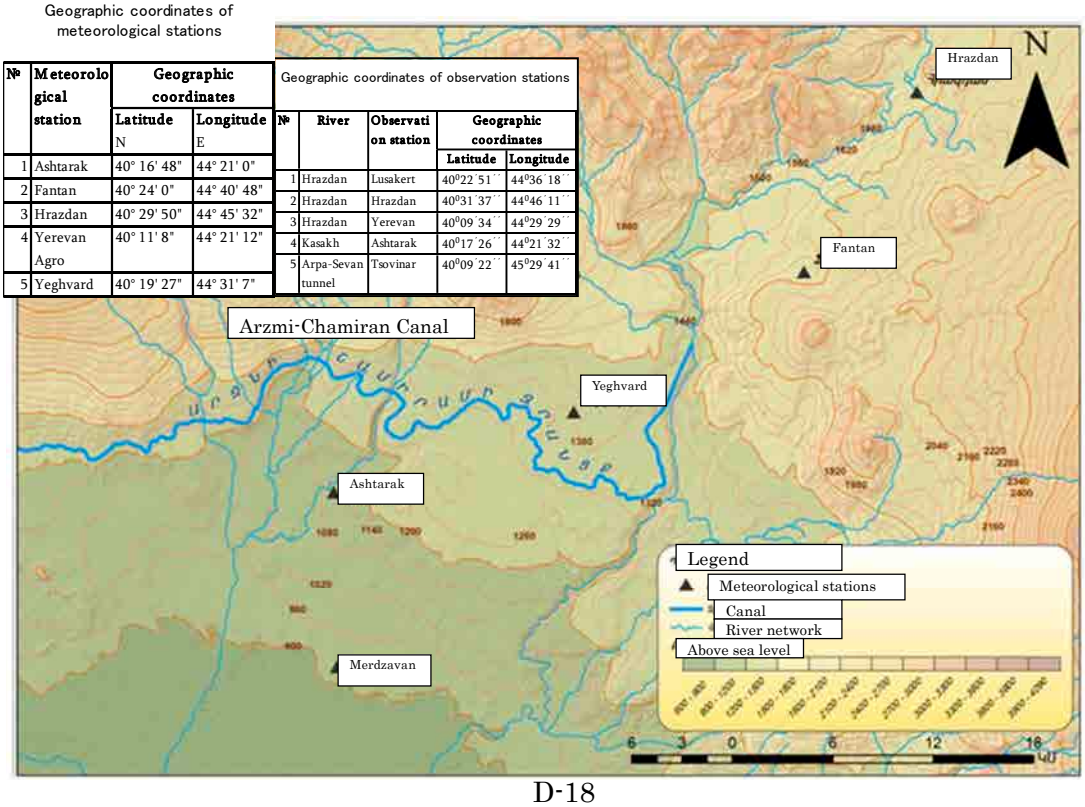
(6) Location Map of Observation Point (Appendix D-6)

Geographic coordinates of meteorological stations

№	Meteorological station	Geographic coordinates	
		Latitude N	Longitude E
1	Ashtarak	40° 16' 48"	44° 21' 0"
2	Fantan	40° 24' 0"	44° 40' 48"
3	Hrazdan	40° 29' 50"	44° 45' 32"
4	Yerevan Agro	40° 11' 8"	44° 21' 12"
5	Yeghvard	40° 19' 27"	44° 31' 7"

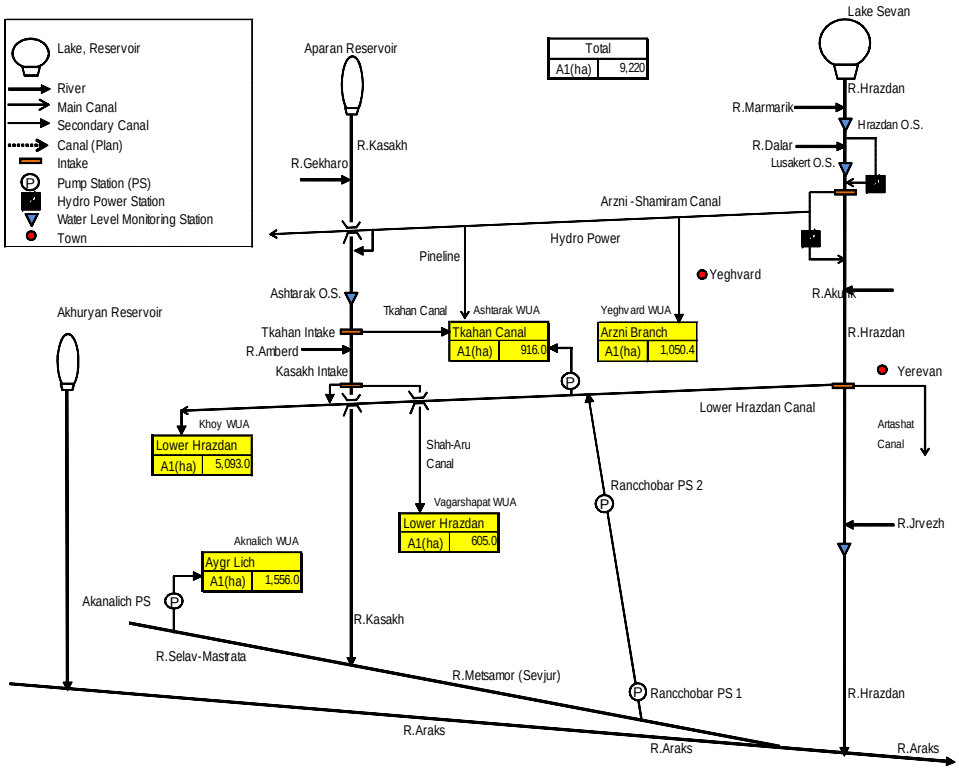
Geographic coordinates of observation stations

№	River	Observation station	Geographic coordinates	
			Latitude	Longitude
1	Hrazdan	Lusakert	40°22´51´´	44°36´18´´
2	Hrazdan	Hrazdan	40°31´37´´	44°46´11´´
3	Hrazdan	Yerevan	40°09´34´´	44°29´29´´
4	Kasakh	Ashtarak	40°17´26´´	44°21´32´´
5	Arpa-Sevan tunnel	Tsovinar	40°09´22´´	45°29´41´´

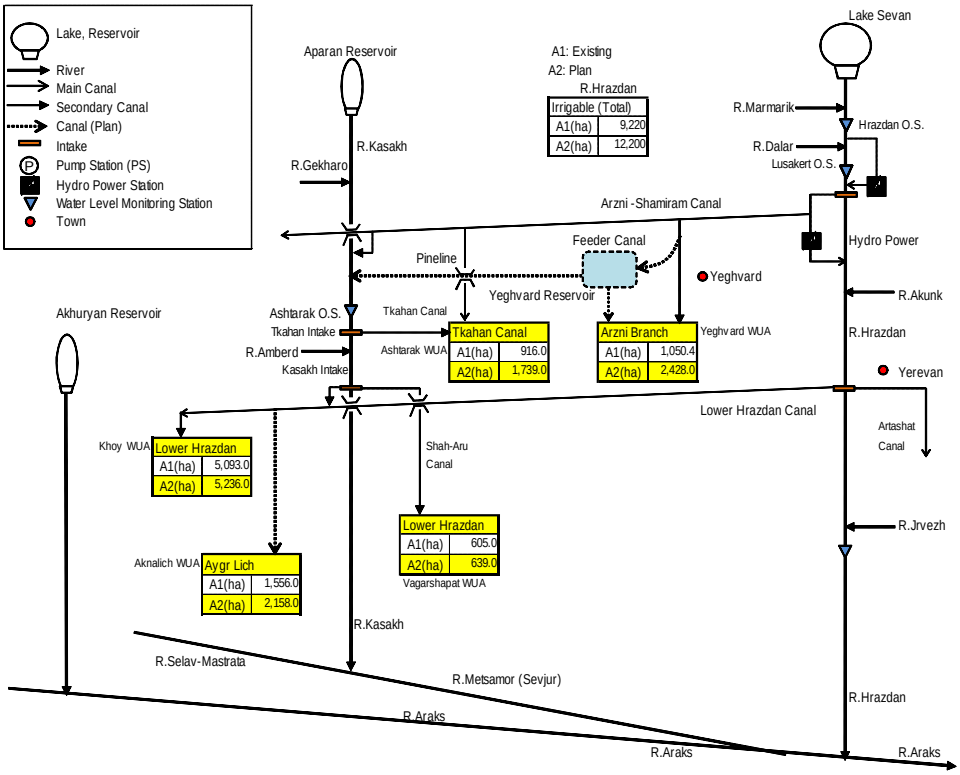


(7) Schematic Diagram of Yeghvard Irrigation Area (Appendix D-7)

(Existing)



(Plan)



(8) Pump Station's Data (Appendix D-8)

No.	Name of community		Farmland are in cadastr ha	Irrigated lands ha	WUA members	Total family members	Managed by WUA		Electric charge in 2013 (kWt/h) thousand
							deep wells	pump station	
Yeghvard WUA									
1	Zovuni		654.2	413.2	867	3468	–	–	–
2	Kasakh		634.0	301.0	325	1300	–	–	–
3	Proshyan		1139.7	336.4	2	8	–	–	–
	Total		2427.9	1050.6	1194	4776	0	0	0
Khoy WUA									
1	Lernamerdz		105.4	69.0	89	356	1	–	0
2	Amberd		352.5	329.0	358	1432	–	3	62.86
3	Aghavnatun		475.5	423.0	658	2632	1	4	1153.08
4	Doghs		285.2	271.0	288	1152	–	–	0
5	Aragats		452.7	587.0	584	2336	3	2	485.23
6	Tsaghkalanj		312.0	477.0	273	1092	1	1	90.48
7	Hovtamej		215.3	211.0	272	1088	6	–	569.8
8	Tsiatsan		205.1	204.0	224	896	3	1	412.64
9	Samaghar		532.6	469.0	639	2556	12	–	698.84
10	Haytagh		647.6	425.0	591	2364	10	1	763.28
11	Ferik		159.0	110.0	72	288	3	–	106.96
12	Arshaluys		1023.0	859.0	787	3148	18	1	1587.68
13	Aknalich		471.0	659.0	543	2172	11	3	1837.87
	Total		5236.9	5093.0	5378	21512	69	16	7768.72
Vagharshapat WUA									
1	Mrgastan		173.6	160.0	319	1276	1	–	100.36
2	Tsaghkunk		138.4	120.0	226	904	4	–	186.32
3	Artimet		327.3	325.0	333	1332	17	–	1000.62
	Total		639.3	605.0	878	3512	22	0	1287.3
ՏՕՀ Ashtarak WUA									
1	Sasunik		1045.8	755.0	723	2892	–	–	–
2	Norakert		130.0	32.0	270	1080	–	–	–
3	Baghramyan		200.0	28.0	349	1396	–	–	–
4	Merdzavan		363.1	100.0	374	1496	–	–	–
	Total		1738.9	915.0	1716	6864	0	0	0
Aknalich WUA									
1	Taronik		404.9	286.0	415	1660	3	–	264.24
2	Artashen		723.8	651.0	662	2648	15	1	910.18
3	khorunk		481.7	322.0	614	2456	10	–	737.1
4	Griboyedov		547.4	297.0	322	1288	5	–	251.38
	Total		2157.8	1556.0	2013	8052	33	1	2162.9
Pump Station									
1	Aknalich							1	1801.00
2	Metsamor							1	1602.02
3	Baghramyan							1	
4	Norakert							2	
5	Merdzavan							3	1651.04
	Total							8	5054.06
	TOTAL		**12201**	**9220**	**11179**	**44716**	**124**	**25**	**16,272.98**

Irrigation Standards for Ararat Plain, Armavir Marz (heavy sand)

No.	Crop	Irrigation Water Volume (m3/ha)																	Total
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	(m3/ha)
1	Wheat	950	950	950	950														3,800
	starting date	(28-Sep)	(20-Apr)	(21-May)	(12-Jun)														
	ending date	(20-Oct)	(20-May)	(11-Jun)	(28-Jun)														
2	Maize	800	800	800	800	800								4,000					
	starting date	(20-Apr)	(17-May)	(17-Jun)	(28-Jun)	(15-Jul)													
	ending date	(16-May)	(17-Jun)	(27-Jun)	(14-Jul)	(29-Jul)													
3	Alfalfa	900	900	900	900	900	900	900	900	900								8,100	
	starting date	(6-Apr)	(12-May)	(1-Jun)	(23-Jun)	(10-Jul)	(26-Jul)	(11-Aug)	(27-Aug)	(18-Sep)									
	ending date	(8-May)	(31-May)	(22-Jun)	(9-Jul)	(25-Jul)	(10-Aug)	(26-Aug)	(17-Sep)	(6-Oct)									
4	Vegetables	650	650	650	650	650	650	650	650	650	650	650	650	650					8,450
	starting date	(10-Apr)	(12-Apr)	(7-May)	(24-May)	(7-Jun)	(21-Jun)	(4-Jul)	(17-Jul)	(29-Jul)	(12-Aug)	(26-Aug)	(10-Sep)	(25-Sep)					
	ending date	(30-Apr)	(1-May)	(23-May)	(6-Jun)	(20-Jun)	(3-Jul)	(16-Jul)	(28-Jul)	(11-Aug)	(25-Aug)	(9-Sep)	(24-Sep)	(7-Oct)					
5	Early variety potato	650	650	650	650	650								3,250					
	starting date	(25-Mar)	(1-May)	(17-May)	(1-Jun)	(14-Jun)													
	ending date	(11-Apr)	(16-May)	(31-May)	(13-Jun)	(26-Jun)													
6	Grape	900	900	900	900	900	900	900	900								7,200		
	starting date	(15-Apr)	(20-May)	(16-Jun)	(1-Jul)	(16-Jul)	(31-Jul)	(14-Aug)	(10-Oct)										
	ending date	(10-May)	(15-Jun)	(30-Jun)	(15-Jul)	(30-Jul)	(13-Aug)	(31-Aug)	(30-Oct)										
7	Orchard	500	500	500	500	500	500	500	500								4,000		
	starting date	(20-Apr)	(23-May)	(18-Jun)	(6-Jul)	(22-Jul)	(6-Aug)	(23-Aug)	(11-Sep)										
	ending date	(20-May)	(17-Jun)	(5-Jul)	(21-Jul)	(5-Aug)	(22-Aug)	(10-Sep)	(5-Oct)										

Irrigation Standards for Ararat Plain, Armavir Marz (heavy sand)

Wheat

N	Irrigation Norm (m3/ha)	From	To	(Days)	(l/s)
0					
1	950	(28-Sep)	(20-Oct)	23	0.478
2	950	(20-Apr)	(20-May)	31	0.355
3	950	(21-May)	(11-Jun)	22	0.500
4	950	(12-Jun)	(28-Jun)	17	0.647
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
	3,800				

Irrigation Standards for Ararat Plain, Armavir Marz (heavy sand)

Vegetable

N	Irrigation Norm (m3/ha)	From	To	(Days)	(l/s)
0					
1	650	(10-Apr)	(30-Apr)	21	0.358
2	650	(12-Apr)	(1-May)	20	0.376
3	650	(7-May)	(23-May)	17	0.443
4	650	(24-May)	(6-Jun)	14	0.537
5	650	(7-Jun)	(20-Jun)	14	0.537
6	650	(21-Jun)	(3-Jul)	13	0.579
7	650	(4-Jul)	(16-Jul)	13	0.579
8	650	(17-Jul)	(28-Jul)	12	0.627
9	650	(29-Jul)	(11-Aug)	14	0.537
10	650	(12-Aug)	(25-Aug)	14	0.537
11	650	(26-Aug)	(9-Sep)	15	0.502
12	650	(10-Sep)	(24-Sep)	15	0.502
13	650	(25-Sep)	(7-Oct)	13	0.579
14		(12-Apr)	(30-Apr)		0.734
15					
	8,450				

Irrigation Standards for Ararat Plain, Armavir Marz (heavy sand)

Grape

N	Irrigation Norm (m3/ha)	From	To	(Days)	(l/s)
0					
1	900	(15-Apr)	(10-May)	26	0.401
2	900	(20-May)	(15-Jun)	27	0.386
3	900	(16-Jun)	(30-Jun)	15	0.694
4	900	(1-Jul)	(15-Jul)	15	0.694
5	900	(16-Jul)	(30-Jul)	15	0.694
6	900	(31-Jul)	(13-Aug)	14	0.744
7	900	(14-Aug)	(31-Aug)	18	0.579
8	900	(10-Oct)	(30-Oct)	21	0.496
9					
10					
11					
12					
13					
14					
15					
	7,200				

Irrigation Standards for Ararat Plain, Armavir Marz (heavy sand)

Alfalfa

N	Irrigation Norm (m3/ha)	From	To	(Days)	(l/s)
0					
1	900	(6-Apr)	(8-May)	33	0.316
2	900	(12-May)	(31-May)	20	0.521
3	900	(1-Jun)	(22-Jun)	22	0.473
4	900	(23-Jun)	(9-Jul)	17	0.613
5	900	(10-Jul)	(25-Jul)	16	0.651
6	900	(26-Jul)	(10-Aug)	16	0.651
7	900	(11-Aug)	(26-Aug)	16	0.651
8	900	(27-Aug)	(17-Sep)	22	0.473
9	900	(18-Sep)	(6-Oct)	19	0.548
10					
11					
12					
13					
14					
15					
	8,100				

Irrigation Standards for Ararat Plain, Armavir Marz (heavy sand)

Fruit

N	Irrigation Norm (m3/ha)	From	To	(Days)	(l/s)
0					
1	500	(20-Apr)	(20-May)	31	0.187
2	500	(23-May)	(17-Jun)	26	0.223
3	500	(18-Jun)	(5-Jul)	18	0.322
4	500	(6-Jul)	(21-Jul)	16	0.362
5	500	(22-Jul)	(5-Aug)	15	0.386
6	500	(6-Aug)	(22-Aug)	17	0.340
7	500	(23-Aug)	(10-Sep)	19	0.305
8	500	(11-Sep)	(5-Oct)	25	0.231
9					
10					
11					
12					
13					
14					
15					
	4,000				

Irrigation Standards for Ararat Plain, Armavir Marz (heavy sand)

Maize

N	Irrigation Norm (m3/ha)	From	To	(Days)	(l/s)
0					
1	800	(20-Apr)	(16-May)	27	0.343
2	800	(17-May)	(17-Jun)	32	0.289
3	800	(17-Jun)	(27-Jun)	11	0.842
4	800	(28-Jun)	(14-Jul)	17	0.545
5	800	(15-Jul)	(29-Jul)	15	0.617
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
	4,000				

(10) Water Requirement for Each Crop (Appendix D-10)

Wheat

Wheat	N	Jan	N	Feb	N	Mar	N	Apr	N	May	N	Jun	N	Jul	N	Aug	N	Sep	N	Oct	N	Nov	N	Dec	
1		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
2		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
3		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
4		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
5		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
6		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
7		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
8		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
9		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
10		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
11		0.000		0.000		0.000		0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000	
12		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
13		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
14		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
15		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
16		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
17		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
18		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
19		0.000		0.000		0.000		0.000	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
20		0.000		0.000		0.000	2	0.355	2	0.355	4	0.647		0.000		0.000		0.000	1	0.478		0.000		0.000	
21		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000		0.000		0.000		0.000		0.000	
22		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000		0.000		0.000		0.000		0.000	
23		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000		0.000		0.000		0.000		0.000	
24		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000		0.000		0.000		0.000		0.000	
25		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000		0.000		0.000		0.000		0.000	
26		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000		0.000		0.000		0.000		0.000	
27		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000		0.000		0.000		0.000		0.000	
28		0.000		0.000		0.000	2	0.355	3	0.500	4	0.647		0.000		0.000	1	0.478		0.000		0.000		0.000	
29		0.000				0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000		0.000	
30		0.000				0.000	2	0.355	3	0.500		0.000		0.000		0.000	1	0.478		0.000		0.000		0.000	
31		0.000				0.000			3	0.500				0.000		0.000				0.000				0.000	
1		0.000		0.000		0.000		0.000		0.355		0.500		0.000		0.000		0.000		0.478		0.000		0.000	(l/s/ha)
2		0.000		0.000		0.000		0.036		0.355		0.632		0.000		0.000		0.000		0.478		0.000		0.000	(l/s/ha)
3		0.000		0.000		0.000		0.355		0.500		0.518		0.000		0.000		0.143		0.000		0.000		0.000	(l/s/ha)
		0		0		0		0		2,075		2,922		0		0		0		2,793		0		0	(l/s)
		0		0		0		207		2,075		3,695		0		0		0		2,793		0		0	(l/s)
		0		0		0		2,075		2,922		3,025		0		0		838		0		0		0	(l/s)
		0		0		0		0		1,793		2,525		0		0		0		2,413		0		0	
		0		0		0		179		1,793		3,192		0		0		0		2,413		0		0	
		0		0		0		1,793		2,777		2,614		0		0		724		0		0		0	(thoudand m3)
		0		0		0		1,972		6,363		8,331		0		0		724		4,826		0		0	22,216.00

Grape

Grape	N	Jan	N	Feb	N	Mar	N	Apr	N	May	N	Jun	N	Jul	N	Aug	N	Sep	N	Oct	N	Nov	N	Dec	
1		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
2		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
3		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
4		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
5		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
6		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
7		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
8		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
9		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000		0.000		0.000		0.000	
10		0.000		0.000		0.000		0.000	1	0.401	2	0.386	4	0.694	6	0.744		0.000	8	0.496		0.000		0.000	
11		0.000		0.000		0.000		0.000		0.000	2	0.386	4	0.694	6	0.744		0.000	8	0.496		0.000		0.000	
12		0.000		0.000		0.000		0.000		0.000	2	0.386	4	0.694	6	0.744		0.000	8	0.496		0.000		0.000	
13		0.000		0.000		0.000		0.000		0.000	2	0.386	4	0.694	6	0.744		0.000	8	0.496		0.000		0.000	
14		0.000		0.000		0.000		0.000		0.000	2	0.386	4	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
15		0.000		0.000		0.000	1	0.401		0.000	2	0.386	4	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
16		0.000		0.000		0.000	1	0.401		0.000	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
17		0.000		0.000		0.000	1	0.401		0.000	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
18		0.000		0.000		0.000	1	0.401		0.000	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
19		0.000		0.000		0.000	1	0.401		0.000	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
20		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
21		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
22		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
23		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
24		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
25		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
26		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
27		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
28		0.000		0.000		0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
29		0.000				0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000	8	0.496		0.000		0.000	
30		0.000				0.000	1	0.401	2	0.386	3	0.694	5	0.694	7	0.579		0.000		0.000		0.000		0.000	
31		0.000				0.000			2	0.386			6	0.744	7	0.579				0.000				0.000	
1		0.000		0.000		0.000		0.000		0.401		0.386		0.694		0.744		0.000		0.050		0.000		0.000	(l/s/ha)
2		0.000		0.000		0.000		0.241		0.039		0.540		0.694		0.629		0.000		0.496		0.000		0.000	(l/s/ha)
3		0.000		0.000		0.000		0.401		0.386		0.694		0.699		0.579		0.000		0.406		0.000		0.000	(l/s/ha)
		0		0		0		0		1,551		1,493		2,684		2,877		0		192		0		0	(l/s)
		0		0		0		931		149		2,088		2,684		2,431		0		1,918		0		0	(l/s)
		0		0		0		1,551		1,493		2,684		2,702		2,239		0		1,570		0		0	(l/s)
		0		0		0		0		1,340		1,290		2,319		2,486		0		166		0		0	
		0		0		0		804		129		1,804		2,319		2,100		0		1,657		0		0	
		0		0		0		1,340		1,419		2,319		2,568		2,128		0		1,492		0		0	(thoudand m3)
		0		0		0		2,144		2,888		5,413		7,206		6,714		0		3,315		0		0	27,680

Fruit

Fruit	N	Jan	N	Feb	N	Mar	N	Apr	N	May	N	Jun	N	Jul	N	Aug	N	Sep	N	Oct	N	Nov	N	Dec	
1		0.000		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000	
2		0.000		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000	
3		0.000		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000	
4		0.000		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000	
5		0.000		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000	
6		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	7	0.305		0.000		0.000		0.000	
7		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	7	0.305		0.000		0.000		0.000	
8		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	7	0.305		0.000		0.000		0.000	
9		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	7	0.305		0.000		0.000		0.000	
10		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	7	0.305		0.000		0.000		0.000	
11		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
12		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
13		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
14		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
15		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
16		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
17		0.000		0.000		0.000		0.000	1	0.187	2	0.223	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
18		0.000		0.000		0.000		0.000	1	0.187	3	0.322	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
19		0.000		0.000		0.000		0.000	1	0.187	3	0.322	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
20		0.000		0.000		0.000	1	0.187	1	0.187	3	0.322	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
21		0.000		0.000		0.000	1	0.187		0.000	3	0.322	4	0.362	6	0.340	8	0.231		0.000		0.000		0.000	
22		0.000		0.000		0.000	1	0.187		0.000	3	0.322	5	0.386	6	0.340	8	0.231		0.000		0.000		0.000	
23		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
24		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
25		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
26		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
27		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
28		0.000		0.000		0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
29		0.000				0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
30		0.000				0.000	1	0.187	2	0.223	3	0.322	5	0.386	7	0.305	8	0.231		0.000		0.000		0.000	
31		0.000				0.000	1		2	0.223				0.000	7	0.305				0.000				0.000	
1		0.000		0.000		0.000		0.000		0.187		0.223		0.342		0.363		0.305		0.116		0.000		0.000	(l/s/ha)
2		0.000		0.000		0.000		0.019		0.187		0.253		0.362		0.340		0.231		0.000		0.000		0.000	(l/s/ha)
3		0.000		0.000		0.000		0.187		0.182		0.322		0.349		0.311		0.231		0.000		0.000		0.000	(l/s/ha)
		0		0		0		0		631		753		1,155		1,226		1,030		390		0		0	(l/s)
		0		0		0		63		631		853		1,222		1,148		780		0		0		0	(l/s)
		0		0		0		631		616		1,087		1,177		1,051		780		0		0		0	(l/s)
		0		0		0		0		545		651		998		1,059		890		337		0		0	
		0		0		0		54		545		737		1,056		992		674		0		0		0	
		0		0		0		545		585		939		1,119		999		674		0		0		0	(thoudand m3)
		0		0		0		599		1,675		2,327		3,173		3,050		2,238		337		0		0	13,399

Vegetable

Vegetable	N	Jan	N	Feb	N	Mar	N	Apr	N	May	N	Jun	N	Jul	N	Aug	N	Sep	N	Oct	N	Nov	N	Dec	
1		0.000		0.000		0.000		0.000		0.000	4	0.537	6	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000	
2		0.000		0.000		0.000		0.000		0.000	4	0.537	6	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000	
3		0.000		0.000		0.000		0.000		0.000	4	0.537	6	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000	
4		0.000		0.000		0.000		0.000		0.000	4	0.537	7	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000	
5		0.000		0.000		0.000		0.000		0.000	4	0.537	7	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000	
6		0.000		0.000		0.000		0.000		0.000	4	0.537	7	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000	
7		0.000		0.000		0.000		0.000	3	0.443	5	0.537	7	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000	
8		0.000		0.000		0.000		0.000	3	0.443	5	0.537	7	0.579	9	0.537	11	0.502		0.000		0.000		0.000	
9		0.000		0.000		0.000		0.000	3	0.443	5	0.537	7	0.579	9	0.537	11	0.502		0.000		0.000		0.000	
10		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	7	0.579	9	0.537	12	0.502		0.000		0.000		0.000	
11		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	7	0.579	9	0.537	12	0.502		0.000		0.000		0.000	
12		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	7	0.579	10	0.537	12	0.502		0.000		0.000		0.000	
13		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	7	0.579	10	0.537	12	0.502		0.000		0.000		0.000	
14		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	7	0.579	10	0.537	12	0.502		0.000		0.000		0.000	
15		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	7	0.579	10	0.537	12	0.502		0.000		0.000		0.000	
16		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	7	0.579	10	0.537	12	0.502		0.000		0.000		0.000	
17		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
18		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
19		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
20		0.000		0.000		0.000	1	0.358	3	0.443	5	0.537	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
21		0.000		0.000		0.000	1	0.358	3	0.443	6	0.579	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
22		0.000		0.000		0.000	1	0.358	3	0.443	6	0.579	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
23		0.000		0.000		0.000	1	0.358	3	0.443	6	0.579	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
24		0.000		0.000		0.000	1	0.358	4	0.537	6	0.579	8	0.627	10	0.537	12	0.502		0.000		0.000		0.000	
25		0.000		0.000		0.000	1	0.358	4	0.537	6	0.579	8	0.627	10	0.537	13	0.579		0.000		0.000		0.000	
26		0.000		0.000		0.000	1	0.358	4	0.537	6	0.579	8	0.627	11	0.502	13	0.579		0.000		0.000		0.000	
27		0.000		0.000		0.000	1	0.358	4	0.537	6	0.579	8	0.627	11	0.502	13	0.579		0.000		0.000		0.000	
28		0.000		0.000		0.000	1	0.358	4	0.537	6	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000		0.000	
29		0.000				0.000	1	0.358	4	0.537	6	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000		0.000	
30		0.000				0.000	1	0.358	4	0.537	6	0.579	9	0.537	11	0.502	13	0.579		0.000		0.000		0.000	
31		0.000				0.000			4	0.537			9	0.537	11	0.502				0.000				0.000	
1		0.000		0.000		0.000		0.036		0.177		0.537		0.579		0.537		0.502		0.405		0.000		0.000	(l/s/ha)
2		0.000		0.000		0.000		0.358		0.443		0.537		0.598		0.537		0.502		0.000		0.000		0.000	(l/s/ha)
3		0.000		0.000		0.000		0.358		0.511		0.579		0.594		0.518		0.548		0.000		0.000		0.000	(l/s/ha)
		0		0		0		172		850		2,576		2,777		2,576		2,408		1,944		0		0	(l/s)
		0		0		0		1,717		2,125		2,576		2,870		2,576		2,408		0		0		0	(l/s)
		0		0		0		1,717		2,453		2,777		2,851		2,484		2,630		0		0		0	(l/s)
		0		0		0		149		734		2,226		2,399		2,226		2,081		1,680		0		0	
		0		0		0		1,483		1,836		2,226		2,480		2,226		2,081		0		0		0	
		0		0		0		1,483		2,331		2,399		2,710		2,361		2,272		0		0		0	(thoudand m3)
		0		0		0		3,115		4,901		6,851		7,589		6,813		6,434		1,680		0		0	37,383

Alfalfa

Alfalfa	N	Jan	N	Feb	N	Mar	N	Apr	N	May	N	Jun	N	Jul	N	Aug	N	Sep	N	Oct	N	Nov	N	Dec	
1		0.000		0.000		0.000		0.000	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000	
2		0.000		0.000		0.000		0.000	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000	
3		0.000		0.000		0.000		0.000	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000	
4		0.000		0.000		0.000		0.000	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000	
5		0.000		0.000		0.000		0.000	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000	
6		0.000		0.000		0.000	1	0.316	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000	
7		0.000		0.000		0.000	1	0.316	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473		0.000		0.000		0.000	
8		0.000		0.000		0.000	1	0.316	1	0.316	3	0.473	4	0.613	6	0.651	8	0.473		0.000		0.000		0.000	
9		0.000		0.000		0.000	1	0.316		0.000	3	0.473	4	0.613	6	0.651	8	0.473		0.000		0.000		0.000	
10		0.000		0.000		0.000	1	0.316		0.000	3	0.473	5	0.651	6	0.651	8	0.473		0.000		0.000		0.000	
11		0.000		0.000		0.000	1	0.316		0.000	3	0.473	5	0.651	7	0.651	8	0.473		0.000		0.000		0.000	
12		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	8	0.473		0.000		0.000		0.000	
13		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	8	0.473		0.000		0.000		0.000	
14		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	8	0.473		0.000		0.000		0.000	
15		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	8	0.473		0.000		0.000		0.000	
16		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	8	0.473		0.000		0.000		0.000	
17		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	8	0.473		0.000		0.000		0.000	
18		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
19		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
20		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
21		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
22		0.000		0.000		0.000	1	0.316	2	0.521	3	0.473	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
23		0.000		0.000		0.000	1	0.316	2	0.521	4	0.613	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
24		0.000		0.000		0.000	1	0.316	2	0.521	4	0.613	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
25		0.000		0.000		0.000	1	0.316	2	0.521	4	0.613	5	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
26		0.000		0.000		0.000	1	0.316	2	0.521	4	0.613	6	0.651	7	0.651	9	0.548		0.000		0.000		0.000	
27		0.000		0.000		0.000	1	0.316	2	0.521	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000		0.000	
28		0.000		0.000		0.000	1	0.316	2	0.521	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000		0.000	
29		0.000				0.000	1	0.316	2	0.521	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000		0.000	
30		0.000				0.000	1	0.316	2	0.521	4	0.613	6	0.651	8	0.473	9	0.548		0.000		0.000		0.000	
31		0.000				0.000			2	0.521			6	0.651	8	0.473				0.000				0.000	
1		0.000		0.000		0.000		0.158		0.253		0.473		0.617		0.651		0.473		0.329		0.000		0.000	(l/s/ha)
2		0.000		0.000		0.000		0.316		0.469		0.473		0.651		0.651		0.496		0.000		0.000		0.000	(l/s/ha)
3		0.000		0.000		0.000		0.316		0.521		0.585		0.651		0.570		0.548		0.000		0.000		0.000	(l/s/ha)
		0		0		0		452		724		1,354		1,766		1,864		1,354		941		0		0	(l/s)
		0		0		0		905		1,343		1,354		1,864		1,864		1,419		0		0		0	(l/s)
		0		0		0		905		1,492		1,675		1,864		1,632		1,569		0		0		0	(l/s)
		0		0		0		391		626		1,170		1,526		1,610		1,170		813		0		0	
		0		0		0		782		1,160		1,170		1,610		1,610		1,226		0		0		0	
		0		0		0		782		1,418		1,447		1,772		1,551		1,356		0		0		0	(thoudand m3)
		0		0		0		1,955		3,204		3,787		4,908		4,771		3,752		813		0		0	23,190

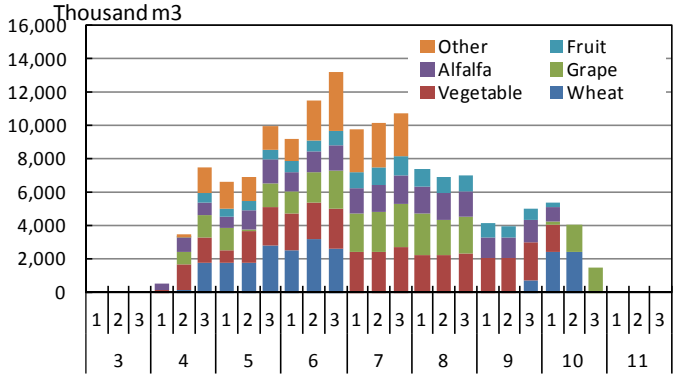
Maize

Maize	N	Jan	N	Feb	N	Mar	N	Apr	N	May	N	Jun	N	Jul	N	Aug	N	Sep	N	Oct	N	Nov	N	Dec	
1		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
2		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
3		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
4		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
5		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
6		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
7		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
8		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
9		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
10		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
11		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
12		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
13		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
14		0.000		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000	
15		0.000		0.000		0.000		0.000	1	0.343	2	0.289	5	0.617		0.000		0.000		0.000		0.000		0.000	
16		0.000		0.000		0.000		0.000	1	0.343	2	0.289	5	0.617		0.000		0.000		0.000		0.000		0.000	
17		0.000		0.000		0.000		0.000	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
18		0.000		0.000		0.000		0.000	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
19		0.000		0.000		0.000		0.000	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
20		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
21		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
22		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
23		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
24		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
25		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
26		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
27		0.000		0.000		0.000	1	0.343	2	0.289	3	0.842	5	0.617		0.000		0.000		0.000		0.000		0.000	
28		0.000		0.000		0.000	1	0.343	2	0.289	4	0.545	5	0.617		0.000		0.000		0.000		0.000		0.000	
29		0.000				0.000	1	0.343	2	0.289	4	0.545	5	0.617		0.000		0.000		0.000		0.000		0.000	
30		0.000				0.000	1	0.343	2	0.289	4	0.545		0.000		0.000		0.000		0.000		0.000		0.000	
31		0.000				0.000			2	0.289				0.000		0.000				0.000				0.000	
1		0.000		0.000		0.000		0.000		0.343		0.289		0.545		0.000		0.000		0.000		0.000		0.000	(l/s/ha)
2		0.000		0.000		0.000		0.034		0.321		0.510		0.588		0.000		0.000		0.000		0.000		0.000	(l/s/ha)
3		0.000		0.000		0.000		0.343		0.289		0.753		0.505		0.000		0.000		0.000		0.000		0.000	(l/s/ha)
		0		0		0		0		1,825		1,538		2,900		0		0		0		0		0	(l/s)
		0		0		0		182		1,710		2,715		3,130		0		0		0		0		0	(l/s)
		0		0		0		1,825		1,538		4,006		2,686		0		0		0		0		0	(l/s)
		0		0		0		0		1,577		1,329		2,506		0		0		0		0		0	
		0		0		0		157		1,477		2,346		2,704		0		0		0		0		0	
		0		0		0		1,577		1,462		3,461		2,553		0		0		0		0		0	(thoudand m3)
		0		0		0		1,734		4,516		7,136		7,763		0		0		0		0		0	21,149

Efficiency 0.468

		1			2			3			4			5			6			7			8			9			10			11			12		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Wheat	2,735	0	0	0	0	0	0	0	0	0	0	179	1,793	1,793	1,793	2,777	2,525	3,192	2,614	0	0	0	0	0	0	0	0	724	2,413	2,413	0	0	0	0	0	0	0
Vegetable	2,245	0	0	0	0	0	0	0	0	0	149	1,483	1,483	734	1,836	2,331	2,226	2,226	2,399	2,399	2,480	2,710	2,226	2,226	2,361	2,081	2,081	2,272	1,680	0	0	0	0	0	0	0	0
Grape	1,810	0	0	0	0	0	0	0	0	0	0	804	1,340	1,340	129	1,419	1,290	1,804	2,319	2,319	2,319	2,568	2,486	2,100	2,128	0	0	0	166	1,657	1,492	0	0	0	0	0	0
Alfalfa	1,340	0	0	0	0	0	0	0	0	0	391	782	782	626	1,160	1,418	1,170	1,170	1,447	1,526	1,610	1,772	1,610	1,610	1,551	1,170	1,226	1,356	813	0	0	0	0	0	0	0	0
Fruit	1,580	0	0	0	0	0	0	0	0	0	0	54	545	545	545	585	651	737	939	998	1,056	1,119	1,059	992	999	890	674	674	337	0	0	0	0	0	0	0	0
Other	2,490	0	0	0	0	0	0	0	0	0	0	157	1,577	1,577	1,477	1,462	1,329	2,346	3,461	2,506	2,704	2,553	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	12,200	0	0	0	0	0	0	0	0	0	540	3,459	7,520	6,615	6,940	9,992	9,191	11,475	13,179	9,748	10,169	10,722	7,381	6,928	7,039	4,141	3,981	5,026	5,409	4,070	1,492	0	0	0			

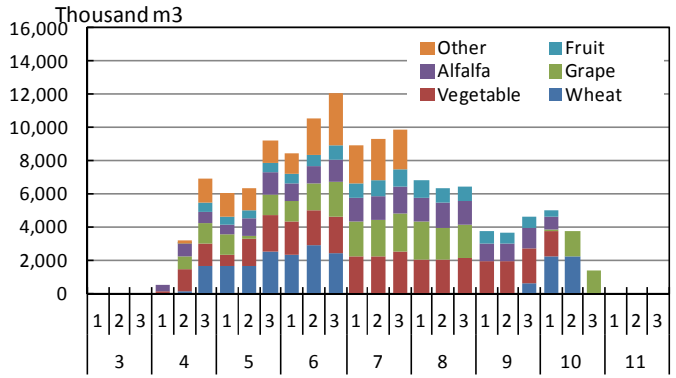
#	#	#	#	#	#	#	0.000	0.000	0.000	0.625	4.003	8.704	7.656	8.032	10.513	10.638	13.281	15.253	11.282	11.770	11.282	8.543	8.019	7.406	4.793	4.608	5.817	6.260	4.711	1.570	0.000	0.000	0.000	#	#	#



Efficiency 0.51

		1			2			3			4			5			6			7			8			9			10			11			12		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Wheat	2,735	0	0	0	0	0	0	0	0	0	0	164	1,645	1,645	1,645	2,548	2,316	2,930	2,398	0	0	0	0	0	0	0	0	664	2,214	2,214	0	0	0	0	0	0	0
Vegetable	2,245	0	0	0	0	0	0	0	0	0	137	1,362	1,362	674	1,685	2,139	2,042	2,042	2,202	2,202	2,275	2,486	2,042	2,042	2,167	1,909	1,909	2,085	1,541	0	0	0	0	0	0	0	0
Grape	1,810	0	0	0	0	0	0	0	0	0	0	738	1,229	1,229	118	1,302	1,184	1,655	2,128	2,128	2,128	2,356	2,281	1,928	1,953	0	0	0	152	1,521	1,369	0	0	0	0	0	0
Alfalfa	1,340	0	0	0	0	0	0	0	0	0	359	717	717	574	1,064	1,301	1,074	1,074	1,328	1,401	1,477	1,625	1,477	1,477	1,424	1,074	1,125	1,244	746	0	0	0	0	0	0	0	0
Fruit	1,580	0	0	0	0	0	0	0	0	0	0	50	500	500	500	537	597	677	862	916	969	1,026	972	910	917	816	619	619	309	0	0	0	0	0	0	0	0
Other	2,490	0	0	0	0	0	0	0	0	0	0	144	1,447	1,447	1,356	1,341	1,219	2,152	3,176	2,299	2,481	2,343	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	12,200	0	0	0	0	0	0	0	0	0	496	3,175	6,900	6,069	6,368	9,168	8,432	10,530	12,094	8,946	9,330	9,836	6,772	6,357	6,461	3,799	3,653	4,612	4,962	3,735	1,369	0	0	0			

#	#	#	#	#	#	0.000	0.000	0.000	0.574	3.675	7.986	7.024	7.370	9.646	9.759	12.188	13.998	10.354	10.799	10.349	7.838	7.358	6.798	4.397	4.228	5.338	5.743	4.323	1.440	0.000	0.000	0.000	#	#	#



(13)Example of Water Balance Caluculation

							Hrazdan River			Lowaer Hrazdan (1st part)					Artashat Canal				
			<Demand> Lower Hrazdan (1st part)	<Demand> Artashat	<Demand> Arzni-Shamiram (2nd part)	<Demand> Other Canals	Hrazdan River (10 years Average)	Ecological flow	Available water of Hrazdan	<Demand> Lower Hrazdan (1st part)	Available water of Hrazdan River (20%)	Supply from Hrazdan River	Remaining water of Hrazdan River	Water deficit (Supplied from Sevan)	<Demand> Artashat	Available water of Hrazdan River (20%)	Supply from Hrazdan River	Remaining water of Hrazdan River	Water deficit (Supplied from Sevan)
			(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Jan	01-10	1	0.000	0.000	0.000	0.000	5.9	1.9	4.0	0.0	0.8	0.0	0.8	0.0	0.0	0.8	0.0	0.8	0.0
	11-20	2	0.000	0.000	0.000	0.000	5.7	1.9	3.8	0.0	0.8	0.0	0.8	0.0	0.0	0.8	0.0	0.8	0.0
	21-31	3	0.000	0.000	0.000	0.000	5.7	1.9	3.8	0.0	0.8	0.0	0.8	0.0	0.0	0.8	0.0	0.8	0.0
Feb	01-10	1	0.000	0.000	0.000	0.000	5.7	1.9	3.8	0.0	0.8	0.0	0.8	0.0	0.0	0.8	0.0	0.8	0.0
	11-20	2	0.000	0.000	0.000	0.000	5.7	1.9	3.8	0.0	0.8	0.0	0.8	0.0	0.0	0.8	0.0	0.8	0.0
	21-28	3	0.000	0.000	0.000	0.000	5.8	1.9	3.9	0.0	0.8	0.0	0.8	0.0	0.0	0.8	0.0	0.8	0.0
Mar	01-10	1	0.000	0.000	0.000	0.000	7.1	1.9	5.2	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0
	11-20	2	0.000	0.000	0.000	0.000	8.8	1.9	6.9	0.0	1.4	0.0	1.4	0.0	0.0	1.4	0.0	1.4	0.0
	21-31	3	0.000	0.000	0.000	0.000	12.5	1.9	10.6	0.0	2.1	0.0	2.1	0.0	0.0	2.1	0.0	2.1	0.0
Apr	01-10	1	0.000	0.000	0.000	0.000	18.8	1.9	16.9	0.0	3.4	0.0	3.4	0.0	0.0	3.4	0.0	3.4	0.0
	11-20	2	3.000	3.500	0.000	0.000	31.5	1.9	29.6	3.0	5.9	3.0	2.9	0.0	3.5	5.9	3.5	2.4	0.0
	21-30	3	3.500	3.500	0.000	0.000	37.8	1.9	35.9	3.5	7.2	3.5	3.7	0.0	3.5	7.2	3.5	3.7	0.0
May	01-10	1	4.000	4.000	7.000	2.386	46.6	1.9	44.7	4.0	8.9	4.0	4.9	0.0	4.0	8.9	4.0	4.9	0.0
	11-20	2	4.000	4.000	7.000	2.388	36.2	1.9	34.3	4.0	6.9	4.0	2.9	0.0	4.0	6.9	4.0	2.9	0.0
	21-31	3	4.000	4.000	10.000	2.842	26.3	1.9	24.4	4.0	4.9	4.0	0.9	0.0	4.0	4.9	4.0	0.9	0.0
Jun	01-10	1	5.000	5.000	13.000	3.865	18.3	1.9	16.4	5.0	3.3	3.3	0.0	1.7	5.0	3.3	3.3	0.0	1.7
	11-20	2	5.000	5.000	13.000	4.621	13.2	1.9	11.3	5.0	2.3	2.3	0.0	2.7	5.0	2.3	2.3	0.0	2.7
	21-30	3	5.000	5.000	13.000	5.183	11.8	1.9	9.9	5.0	2.0	2.0	0.0	3.0	5.0	2.0	2.0	0.0	3.0
Jul	01-10	1	5.000	5.000	13.000	5.262	9.9	1.9	8.0	5.0	1.6	1.6	0.0	3.4	5.0	1.6	1.6	0.0	3.4
	11-20	2	5.000	5.000	13.000	5.521	8.5	1.9	6.6	5.0	1.3	1.3	0.0	3.7	5.0	1.3	1.3	0.0	3.7
	21-31	3	5.000	5.000	13.000	5.635	7.9	1.9	6.0	5.0	1.2	1.2	0.0	3.8	5.0	1.2	1.2	0.0	3.8
Aug	01-10	1	5.000	5.000	13.000	4.982	7.4	1.9	5.5	5.0	1.1	1.1	0.0	3.9	5.0	1.1	1.1	0.0	3.9
	11-20	2	5.000	5.000	13.000	4.881	6.9	1.9	5.0	5.0	1.0	1.0	0.0	4.0	5.0	1.0	1.0	0.0	4.0
	21-31	3	5.000	5.000	13.000	4.356	7.0	1.9	5.1	5.0	1.0	1.0	0.0	4.0	5.0	1.0	1.0	0.0	4.0
Sep	01-10	1	4.000	4.000	8.000	2.759	6.7	1.9	4.8	4.0	1.0	1.0	0.0	3.0	4.0	1.0	1.0	0.0	3.0
	11-20	2	4.000	4.000	8.000	2.303	6.9	1.9	5.0	4.0	1.0	1.0	0.0	3.0	4.0	1.0	1.0	0.0	3.0
	21-30	3	4.000	4.000	8.000	1.534	6.9	1.9	5.0	4.0	1.0	1.0	0.0	3.0	4.0	1.0	1.0	0.0	3.0
Oct	01-10	1	4.000	4.000	5.000	1.136	7.3	1.9	5.4	4.0	1.1	1.1	0.0	2.9	4.0	1.1	1.1	0.0	2.9
	11-20	2	4.000	4.000	5.000	0.000	7.2	1.9	5.3	4.0	1.1	1.1	0.0	2.9	4.0	1.1	1.1	0.0	2.9
	21-31	3	3.000	4.000	5.000	0.000	7.4	1.9	5.5	3.0	1.1	1.1	0.0	1.9	4.0	1.1	1.1	0.0	2.9
Nov	01-10	1	0.000	0.000	0.000	0.000	8.3	1.9	6.4	0.0	1.3	0.0	1.3	0.0	0.0	1.3	0.0	1.3	0.0
	11-20	2	0.000	0.000	0.000	0.000	7.6	1.9	5.7	0.0	1.1	0.0	1.1	0.0	0.0	1.1	0.0	1.1	0.0
	21-30	3	0.000	0.000	0.000	0.000	6.9	1.9	5.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0
Dec	01-10	1	0.000	0.000	0.000	0.000	6.6	1.9	4.7	0.0	0.9	0.0	0.9	0.0	0.0	0.9	0.0	0.9	0.0
	11-20	2	0.000	0.000	0.000	0.000	6.5	1.9	4.6	0.0	0.9	0.0	0.9	0.0	0.0	0.9	0.0	0.9	0.0
	21-31	3	0.000	0.000	0.000	0.000	6.3	1.9	4.4	0.0	0.9	0.0	0.9	0.0	0.0	0.9	0.0	0.9	0.0
			76.2	**77.6**	**159.1**	**52.6**	**381.6**	**59.9**	**321.7**	**76.2**	**64.6**	**34.8**	**29.7**	**41.4**	**77.6**	**64.6**	**35.3**	**29.3**	**42.3**

(13)Example of W

			Arzni-Shamiram (2nd part)											Other Canals					Total	
			<Demand> Arzni-Shamiram (2nd part)	Available wate of Amberd River	Supply from Armbed River	Water deficit after using of Armbed River	Availabule water of Aparan Reservoir	Supply from Aparan Reservoir	Water deficit after using of Aparan Reservoir	Available water of Hrazdan River (40%)	Supply from Hrazdan River through Arzni-shamiram	Remaining water of Hrazdan River	Water deficit (Supplied from Sevan)	<Demand> Other Canals	Available water of Hrazdan River (20%)	Supply from Hrazdan River	Remaining water of Hrazdan River	Water deficit (Supplied from Sevan)	Remaining water of Hrazdan River	Water deficit for other areas(Supplied from Sevan)
			(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Jan	01-10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.6	0.0	0.0	0.8	0.0	0.8	0.0	4.0	0.0
	11-20	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5	0.0	0.0	0.8	0.0	0.8	0.0	3.9	0.0
	21-31	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5	0.0	0.0	0.8	0.0	0.8	0.0	3.9	0.0
Feb	01-10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5	0.0	0.0	0.8	0.0	0.8	0.0	3.9	0.0
	11-20	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5	0.0	0.0	0.8	0.0	0.8	0.0	3.9	0.0
	21-28	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.6	0.0	0.0	0.8	0.0	0.8	0.0	4.0	0.0
Mar	01-10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	2.1	0.0	0.0	1.0	0.0	1.0	0.0	5.1	0.0
	11-20	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	2.7	0.0	0.0	1.4	0.0	1.4	0.0	6.9	0.0
	21-31	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	4.3	0.0	0.0	2.1	0.0	2.1	0.0	10.6	0.0
Apr	01-10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	6.8	0.0	0.0	3.4	0.0	3.4	0.0	17.0	0.0
	11-20	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0	11.8	0.0	0.0	5.9	0.0	5.9	0.0	23.0	0.0
	21-30	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	14.3	0.0	0.0	7.2	0.0	7.2	0.0	28.9	0.0
May	01-10	1	7.0	4.0	4.0	3.0	0.0	0.0	3.0	17.9	3.0	14.9	0.0	2.4	8.9	2.4	6.5	0.0	31.2	0.0
	11-20	2	7.0	4.0	4.0	3.0	0.0	0.0	3.0	13.7	3.0	10.7	0.0	2.4	6.9	2.4	4.5	0.0	21.0	0.0
	21-31	3	10.0	0.0	0.0	10.0	0.9	0.9	9.1	9.8	9.1	0.7	0.0	2.8	4.9	2.8	2.1	0.0	4.6	0.0
Jun	01-10	1	13.0	0.0	0.0	13.0	8.4	8.4	4.6	6.6	4.6	2.0	0.0	3.9	3.3	3.3	0.0	0.6	2.0	4.0
	11-20	2	13.0	0.0	0.0	13.0	10.0	10.0	3.0	4.5	3.0	1.5	0.0	4.6	2.3	2.3	0.0	2.3	1.5	7.7
	21-30	3	13.0	0.0	0.0	13.0	10.0	10.0	3.0	3.9	3.0	0.9	0.0	5.2	2.0	2.0	0.0	3.2	0.9	9.2
Jul	01-10	1	13.0	0.0	0.0	13.0	10.0	10.0	3.0	3.2	3.0	0.2	0.0	5.3	1.6	1.6	0.0	3.7	0.2	10.5
	11-20	2	13.0	0.0	0.0	13.0	8.3	8.3	4.7	2.6	2.6	0.0	2.1	5.5	1.3	1.3	0.0	4.2	0.0	13.7
	21-31	3	13.0	0.0	0.0	13.0	0.0	0.0	13.0	2.4	2.4	0.0	10.6	5.6	1.2	1.2	0.0	4.4	0.0	22.6
Aug	01-10	1	13.0	0.0	0.0	13.0	0.0	0.0	13.0	2.2	2.2	0.0	10.8	5.0	1.1	1.1	0.0	3.9	0.0	22.5
	11-20	2	13.0	0.0	0.0	13.0	0.0	0.0	13.0	2.0	2.0	0.0	11.0	4.9	1.0	1.0	0.0	3.9	0.0	22.9
	21-31	3	13.0	0.0	0.0	13.0	0.0	0.0	13.0	2.0	2.0	0.0	11.0	4.4	1.0	1.0	0.0	3.4	0.0	22.4
Sep	01-10	1	8.0	0.0	0.0	8.0	0.0	0.0	8.0	1.9	1.9	0.0	6.1	2.8	1.0	1.0	0.0	1.8	0.0	13.9
	11-20	2	8.0	0.0	0.0	8.0	0.0	0.0	8.0	2.0	2.0	0.0	6.0	2.3	1.0	1.0	0.0	1.3	0.0	13.3
	21-30	3	8.0	0.0	0.0	8.0	0.0	0.0	8.0	2.0	2.0	0.0	6.0	1.5	1.0	1.0	0.0	0.5	0.0	12.5
Oct	01-10	1	5.0	0.0	0.0	5.0	0.0	0.0	5.0	2.2	2.2	0.0	2.8	1.1	1.1	1.1	0.0	0.0	0.0	8.6
	11-20	2	5.0	0.0	0.0	5.0	0.0	0.0	5.0	2.1	2.1	0.0	2.9	0.0	1.1	0.0	1.1	0.0	1.1	8.7
	21-31	3	5.0	0.0	0.0	5.0	0.0	0.0	5.0	2.2	2.2	0.0	2.8	0.0	1.1	0.0	1.1	0.0	1.1	7.6
Nov	01-10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5	0.0	0.0	1.3	0.0	1.3	0.0	6.4	0.0
	11-20	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	2.3	0.0	0.0	1.1	0.0	1.1	0.0	5.6	0.0
	21-30	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	0.0	1.0	0.0	5.0	0.0
Dec	01-10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.9	0.0	0.0	0.9	0.0	0.9	0.0	4.6	0.0
	11-20	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	1.8	0.0	0.0	0.9	0.0	0.9	0.0	4.5	0.0
	21-31	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	1.7	0.0	0.0	0.9	0.0	0.9	0.0	4.4	0.0
			159.1	**6.9**	**6.9**	**152.2**	**41.2**	**41.2**	**110.9**	**128.5**	**46.5**	**81.9**	**64.4**	**52.7**	**64.6**	**23.3**	**41.2**	**29.4**	**182.2**	**177.4**

(13)Example of W			Yeghvard Project Area			Kasak River			Vagarshapat, Khoy and Aknalich WUA									Yeghvard WUA and Ashtarak WUA				
			12200ha	Yeghvard WUA and Ashtarak WUA	Vagarshapat, Khoy and Aknalich WUA	Kasakh River (10 years Average)	Ecological flow	Available water of Kasakh River	Vagarshapat, Khoy and Aknalich WUA	Available water of Kasakh River	Supply from Kasakh River	Remainig water of Kasakh Rivver	Water deficit after using of Kasakh River	Remaining water of Hrazdan River	Supply from Hrazdan River through Lower Hrazdan	Remaining water of Hrazdan River	Water deficit (Supplied from Yeghvard Res.)	Yeghvard WUA and Ashtarak WUA	Remaining water of Hrazdan River	Supply from Hrazdan River through Arzni-Shamiram	Remaining water of Hrazdan River	Water deficit (Supplied from Yeghvard Res.)
			(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Jan	01-10	1	0.000	0.0	0.0	2.7	0.0	2.7	0.0	2.7	0.0	2.7	0.0	4.0	0.0	4.0	0.0	0.0	4.0	0.0	4.0	0.0
	11-20	2	0.000	0.0	0.0	2.7	0.0	2.7	0.0	2.7	0.0	2.7	0.0	3.9	0.0	3.9	0.0	0.0	3.9	0.0	3.9	0.0
	21-31	3	0.000	0.0	0.0	2.7	0.0	2.7	0.0	2.7	0.0	2.7	0.0	3.9	0.0	3.9	0.0	0.0	3.9	0.0	3.9	0.0
Feb	01-10	1	0.000	0.0	0.0	2.7	0.0	2.7	0.0	2.7	0.0	2.7	0.0	3.9	0.0	3.9	0.0	0.0	3.9	0.0	3.9	0.0
	11-20	2	0.000	0.0	0.0	2.8	0.0	2.8	0.0	2.8	0.0	2.8	0.0	3.9	0.0	3.9	0.0	0.0	3.9	0.0	3.9	0.0
	21-28	3	0.000	0.0	0.0	2.9	0.0	2.9	0.0	2.9	0.0	2.9	0.0	4.0	0.0	4.0	0.0	0.0	4.0	0.0	4.0	0.0
Mar	01-10	1	0.000	0.0	0.0	3.2	0.0	3.0	0.0	3.0	0.0	3.0	0.0	5.1	0.0	5.1	0.0	0.0	5.1	0.0	5.1	0.0
	11-20	2	0.000	0.0	0.0	3.2	0.0	3.0	0.0	3.0	0.0	3.0	0.0	6.9	0.0	6.9	0.0	0.0	6.9	0.0	6.9	0.0
	21-31	3	0.000	0.0	0.0	3.8	0.0	3.0	0.0	3.0	0.0	3.0	0.0	10.6	0.0	10.6	0.0	0.0	10.6	0.0	10.6	0.0
Apr	01-10	1	0.625	0.1	0.5	5.7	0.0	3.0	0.5	3.0	0.5	2.5	0.0	17.0	0.0	17.0	0.0	0.1	17.0	0.1	16.9	0.0
	11-20	2	4.005	0.8	3.2	6.3	0.0	3.0	3.2	3.0	3.0	0.0	0.2	23.0	0.2	22.8	0.0	0.8	22.8	0.8	22.0	0.0
	21-30	3	8.704	1.7	7.0	5.3	0.0	3.0	7.0	3.0	3.0	0.0	4.0	28.9	4.0	24.9	0.0	1.7	24.9	1.7	23.2	0.0
May	01-10	1	7.655	1.5	6.1	4.7	0.0	3.0	6.1	3.0	3.0	0.0	3.1	31.2	3.1	28.1	0.0	1.5	28.1	1.5	26.6	0.0
	11-20	2	8.034	1.6	6.4	3.5	0.0	3.0	6.4	3.0	3.0	0.0	3.4	21.0	3.4	17.6	0.0	1.6	17.6	1.6	16.0	0.0
	21-31	3	10.513	2.1	8.4	2.9	0.0	2.9	8.4	2.9	2.9	0.0	5.5	4.6	4.6	0.0	0.9	2.1	0.0	0.0	0.0	2.1
Jun	01-10	1	10.638	2.1	8.5	2.8	0.0	2.8	8.5	2.8	2.8	0.0	5.7	2.0	2.0	0.0	3.7	2.1	0.0	0.0	0.0	2.1
	11-20	2	13.280	2.7	10.6	2.9	0.0	2.9	10.6	2.9	2.9	0.0	7.7	1.5	1.5	0.0	6.2	2.7	0.0	0.0	0.0	2.7
	21-30	3	15.253	3.1	12.2	2.9	0.0	2.9	12.2	2.9	2.9	0.0	9.3	0.9	0.9	0.0	8.4	3.1	0.0	0.0	0.0	3.1
Jul	01-10	1	11.284	2.3	9.0	2.8	0.0	2.8	9.0	2.8	2.8	0.0	6.2	0.2	0.2	0.0	6.0	2.3	0.0	0.0	0.0	2.3
	11-20	2	11.770	2.4	9.4	2.6	0.0	2.6	9.4	2.6	2.6	0.0	6.8	0.0	0.0	0.0	6.8	2.4	0.0	0.0	0.0	2.4
	21-31	3	11.282	2.3	9.0	2.5	0.0	2.5	9.0	2.5	2.5	0.0	6.5	0.0	0.0	0.0	6.5	2.3	0.0	0.0	0.0	2.3
Aug	01-10	1	8.544	1.7	6.8	2.5	0.0	2.5	6.8	2.5	2.5	0.0	4.3	0.0	0.0	0.0	4.3	1.7	0.0	0.0	0.0	1.7
	11-20	2	8.020	1.6	6.4	2.6	0.0	2.6	6.4	2.6	2.6	0.0	3.8	0.0	0.0	0.0	3.8	1.6	0.0	0.0	0.0	1.6
	21-31	3	7.408	1.5	5.9	2.6	0.0	2.6	5.9	2.6	2.6	0.0	3.3	0.0	0.0	0.0	3.3	1.5	0.0	0.0	0.0	1.5
Sep	01-10	1	4.793	1.0	3.8	2.7	0.0	2.7	3.8	2.7	2.7	0.0	1.1	0.0	0.0	0.0	1.1	1.0	0.0	0.0	0.0	1.0
	11-20	2	4.608	0.9	3.7	2.5	0.0	2.5	3.7	2.5	2.5	0.0	1.2	0.0	0.0	0.0	1.2	0.9	0.0	0.0	0.0	0.9
	21-30	3	5.818	1.2	4.7	2.6	0.0	2.6	4.7	2.6	2.6	0.0	2.1	0.0	0.0	0.0	2.1	1.2	0.0	0.0	0.0	1.2
Oct	01-10	1	6.260	1.3	5.0	2.7	0.0	2.7	5.0	2.7	2.7	0.0	2.3	0.0	0.0	0.0	2.3	1.3	0.0	0.0	0.0	1.3
	11-20	2	4.711	0.9	3.8	2.9	0.0	2.9	3.8	2.9	2.9	0.0	0.9	1.1	0.9	0.2	0.0	0.9	0.2	0.2	0.0	0.7
	21-31	3	1.570	0.3	1.3	2.9	0.0	2.9	1.3	2.9	1.3	1.6	0.0	1.1	0.0	1.1	0.0	0.3	1.1	0.3	0.8	0.0
Nov	01-10	1	0.000	0.0	0.0	3.0	0.0	3.0	0.0	3.0	0.0	3.0	0.0	6.4	0.0	6.4	0.0	0.0	6.4	0.0	6.4	0.0
	11-20	2	0.000	0.0	0.0	3.1	0.0	3.0	0.0	3.0	0.0	3.0	0.0	5.6	0.0	5.6	0.0	0.0	5.6	0.0	5.6	0.0
	21-30	3	0.000	0.0	0.0	3.0	0.0	3.0	0.0	3.0	0.0	3.0	0.0	5.0	0.0	5.0	0.0	0.0	5.0	0.0	5.0	0.0
Dec	01-10	1	0.000	0.0	0.0	2.8	0.0	2.8	0.0	2.8	0.0	2.8	0.0	4.6	0.0	4.6	0.0	0.0	4.6	0.0	4.6	0.0
	11-20	2	0.000	0.0	0.0	2.7	0.0	2.7	0.0	2.7	0.0	2.7	0.0	4.5	0.0	4.5	0.0	0.0	4.5	0.0	4.5	0.0
	21-31	3	0.000	0.0	0.0	2.7	0.0	2.7	0.0	2.7	0.0	2.7	0.0	4.4	0.0	4.4	0.0	0.0	4.4	0.0	4.4	0.0
			145.0	**29.1**	**115.9**	**98.7**	**0.0**	**88.4**	**115.9**	**88.4**	**47.6**	**40.9**	**68.3**	**182.2**	**18.4**	**163.8**	**50.0**	**29.1**	**163.8**	**5.4**	**158.4**	**23.8**

(13)Example of Wa

								Water Deficit							Supplied from Savan			Total Water Use of River and Reservoir				
			Water use through Arzni-shmiram(2nd Part)	Water use for Yeghvard and Ashtarak WUA through Arzni-shmiram	flag (1:Usage period of Yeghvard)	Dischrge of Arzni-Shamiram canal	Dischrge of Arzni-Shamiram canal(Volume)	Vara,Khoy, Akana	Yeg,Ash	Total	Evaporation from Reservoir(0.14m3/s)	Reservoir Loss(0.24 m3/s)	Reservor Volume	Water deficit of Yeghvard Reservoir	Other canals	Project Area	Total	Hrazdan	Amberd	Apran	Kasakh	Remaining water of Hrazdan River
			(m3/s)	(m3/s)		(m3/s)	(MCM)	(m3/s)	(m3/s)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(m3/s)	(m3/s)						(m3/s)
Jan	01-10	1	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
	11-20	2	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
	21-31	3	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
Feb	01-10	1	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
	11-20	2	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
	21-28	3	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
Mar	01-10	1	0.0	0.0	1	5.1	4.4	0.0	0.0	0.0	0.12	0.21	4.1	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0
	11-20	2	0.0	0.0	1	6.9	6.0	0.0	0.0	0.0	0.12	0.21	9.7	0.0	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0
	21-31	3	0.0	0.0	1	10.6	10.1	0.0	0.0	0.0	0.13	0.23	19.5	0.0	0.0	0.0	0.0	10.6	0.0	0.0	0.0	0.0
Apr	01-10	1	0.0	0.1	1	16.9	14.6	0.0	0.0	0.0	0.12	0.21	33.8	0.0	0.0	0.0	0.0	17.0	0.0	0.0	0.5	0.0
	11-20	2	0.0	0.8	1	16.2	14.0	0.0	0.0	0.0	0.12	0.21	47.4	0.0	0.0	0.0	0.0	23.7	0.0	0.0	3.0	5.8
	21-30	3	0.0	1.7	1	15.3	13.2	0.0	0.0	0.0	0.12	0.21	60.3	0.0	0.0	0.0	0.0	28.0	0.0	0.0	3.0	7.9
May	01-10	1	3.0	1.5	1	12.5	10.8	0.0	0.0	0.0	0.12	0.21	70.8	0.0	0.0	0.0	0.0	30.5	4.0	0.0	3.0	14.1
	11-20	2	3.0	1.6	1	12.4	10.7	0.0	0.0	0.0	0.12	0.21	81.1	0.0	0.0	0.0	0.0	30.8	4.0	0.0	3.0	3.6
	21-31	3	9.1	0.0	1	0.0	0.0	0.9	2.1	2.9	0.13	0.23	77.9	0.0	0.0	0.0	0.0	24.5	0.0	0.9	2.9	0.0
Jun	01-10	1	4.6	0.0	1	0.0	0.0	3.7	2.1	5.0	0.12	0.21	72.5	0.0	4.0	0.0	4.0	16.5	0.0	8.4	2.8	0.0
	11-20	2	3.0	0.0	1	0.0	0.0	6.2	2.7	7.7	0.12	0.21	64.5	0.0	7.7	0.0	7.7	11.4	0.0	10.0	2.9	0.0
	21-30	3	3.0	0.0	1	0.0	0.0	8.4	3.1	9.9	0.12	0.21	54.3	0.0	9.2	0.0	9.2	9.9	0.0	10.0	2.9	0.0
Jul	01-10	1	3.0	0.0	1	0.0	0.0	6.0	2.3	7.2	0.12	0.21	46.8	0.0	10.5	0.0	10.5	8.0	0.0	10.0	2.8	0.0
	11-20	2	2.6	0.0	1	0.0	0.0	6.8	2.4	8.0	0.12	0.21	38.4	0.0	13.7	0.0	13.7	6.5	0.0	8.3	2.6	0.0
	21-31	3	2.4	0.0	1	0.0	0.0	6.5	2.3	8.4	0.13	0.23	29.7	0.0	22.6	0.0	22.6	6.0	0.0	0.0	2.5	0.0
Aug	01-10	1	2.2	0.0	1	0.0	0.0	4.3	1.7	5.2	0.12	0.21	24.1	0.0	22.5	0.0	22.5	5.5	0.0	0.0	2.5	0.0
	11-20	2	2.0	0.0	1	0.0	0.0	3.8	1.6	4.7	0.12	0.21	19.1	0.0	22.9	0.0	22.9	5.0	0.0	0.0	2.6	0.0
	21-31	3	2.0	0.0	1	0.0	0.0	3.3	1.5	4.6	0.13	0.23	14.1	0.0	22.4	0.0	22.4	5.0	0.0	0.0	2.6	0.0
Sep	01-10	1	1.9	0.0	1	0.0	0.0	1.1	1.0	1.8	0.12	0.21	12.0	0.0	13.9	0.0	13.9	4.9	0.0	0.0	2.7	0.0
	11-20	2	2.0	0.0	1	0.0	0.0	1.2	0.9	1.8	0.12	0.21	9.9	0.0	13.3	0.0	13.3	5.0	0.0	0.0	2.5	0.0
	21-30	3	2.0	0.0	1	0.0	0.0	2.1	1.2	2.9	0.12	0.21	6.7	0.0	12.5	0.0	12.5	5.0	0.0	0.0	2.6	0.0
Oct	01-10	1	2.2	0.0	1	0.0	0.0	2.3	1.3	3.1	0.12	0.21	3.2	0.0	8.6	0.0	8.6	5.5	0.0	0.0	2.7	0.0
	11-20	2	2.1	0.2	1	0.0	0.0	0.0	0.7	0.6	0.12	0.21	2.3	0.0	8.7	0.0	8.7	5.4	0.0	0.0	2.9	0.0
	21-31	3	2.2	0.3	1	0.8	0.8	0.0	0.0	0.0	0.13	0.23	2.7	0.0	7.6	0.0	7.6	5.5	0.0	0.0	1.3	0.0
Nov	01-10	1	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4
	11-20	2	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6
	21-30	3	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
Dec	01-10	1	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6
	11-20	2	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5
	21-31	3	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.00	0.00	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
			46.5	**5.4**		**84.5**	**84.6**	**50.0**	**23.8**	**73.8**	**2.9**	**5.1**	**0.0**	**0.0**	**177.4**	**0.0**	**177.4**	**248.3**	**6.9**	**41.2**	**47.6**	**73.9**

Appendix-E Supporting Information of Yeghvard Reservoir

1. Reservoir Planning, Dam Design and existing conditions

1-1 Original reservoir planning and the dam design

(1) Investigation of embankment materials

According to the report "WATER RESERVOIR ON HRAZDAN RIVER, (YEGHVARD RESERVOIR), VOLUME IV, NATURAL CONDITIONS, BOOK 2, ENGINEERING-GEOLOGICAL AND HYDRO-GEOLOGICAL CONDITIONS, 1985", followings were grasped in terms of the embankment materials.

i) Impervious materials

Location of borrow area	Investigation	Soil type	Area (ha)	Average depth (m)	Available quantity ($\times 10^6 m^3$)
Reservoir basin	- Pit/borehole excavation - Vertical electrical sounding	Loamy sand/soils	312.7	17.1	53.5

ii) Sand-and-gravel materials (Pebblestone)

Location of borrow area	Investigation	Soil type	Area (ha)	Ave. depth (m)	Available quantity ($\times 10^6 m^3$)
Reservoir north slope	Borehole ex. VES survey	Pebble - Gravely soils	154.6	6.6	10.26
Outer side of the above			158.0	10.4	16.38
Total			312.6		26.64

iii) Rock materials

Location of borrow area	Investigation	Soil type	Available quantity ($\times 10^6 m^3$)
Quarry near Karpi Village	Field visit	Basaltic andesites	1.5

iv) Sand materials

Location of borrow area	Note
Armavir Deposit of alluvial sands	L=60 km
Sieving and washing to sand-and-gravels in the reservoir quarry	

(2) Laboratory soil test

i) Impervious materials

a) Physical soil test

Item \ Result		Min.	Max.	Average	No. of samples
Field moisture content		15.2%	33.0%	23.7%	N=18
Specific gravity		2.64	2.72	2.68	N=74
Particle size distribution	2.0 - 40.0mm	0.0%	13.0%	1.18%	N=75
	1.0 - 2.0mm	0.0%	9.35%	0.86%	N=75
	0.5 - 1.0mm	0.0%	8.8%	0.96%	N=75
	0.25 - 0.5mm	0.1%	20.91%	2.91%	N=75
	0.05 - 0.25mm	23.67%	74.28%	49.1%	N=75
	0.01 - 0.05mm	4.13%	45.71%	23.05%	N=75
	0.005 - 0.01mm	0.73%	29.7%	7.45%	N=75

	- 0.005mm	2.34%	26.06%	14.49%	N=75
Atterberg limit	Liquid limit	21.0%	40.0%	30.8%	N=74
	Plastic limit	17.9%	33.5%	25.4%	N=74
	Plasticity index	1.4%	12.4%	5.4%	N=74
Field density	Wet density (g/cm^3)	1.31	1.63	1.52	N=21
	Dry density (g/cm^3)	1.20	1.44	1.32	N=21

b) Mechanical soil test

Item \ Result		Min.	Max.	Average	No. of samples
Compaction test	Wopt (%)	21.0%	28.0%	25.0%	N=21
	ρdmax (g/cm^3)	1.42	1.59	1.50	
Direct shear test	Friction angle (°)	14°00'	22°00'	17°55' (17°15')	At Wopt (Wopt, saturated)
	Cohesion(kg/cm^2)	0.20	0.40	0.29 (0.28)	At Wopt (Wopt, saturated)
Consolidation test	Deformation modu.	97	215	155	(kg/cm^2), N=8
	Compression ratio	0.001	0.006	0.003	

∗Wopt ;Optimum moisture content, ρdmax; Maximum dry density

ii) Sand-and-gravel (Pebble)materials

a) Physical soil test

Item \ Result		Min.	Max.	Average	No. of samples
Field moisture content		12.2%	14.4%	13.2%	N=7
Specific gravity		2.71	2.74	2.73	N=7
Particle size distribution	200 - 400mm	2.18%	11.2%	6.2%	N=16
	40.0 - 200mm	10.4%	33.48%	19.95%	
	20.0 - 40.0mm	10.35%	30.48%	18.65%	
	10.0 - 20.0mm	4.85%	16.2%	10.24%	
	7.0 - 10.0mm	6.0%	15.0%	10.5%	
	5.0 - 7.0mm	8.0%	16.0%	12.0%	
	2.0 - 5.0mm	2.75%	10.14%	6.5%	
	0.5 - 2.0mm	1.14%	8.13%	3.9%	
	0.25 - 0.5mm	1.63%	5.14%	3.72%	
	0.1 - 0.25mm	2.18%	6.18%	4.16%	
	0.05 - 0.1mm	1.7%	6.75%	3.93%	
	0.01 - 0.05mm	3.02%	6.36%	4.21%	
	0.005 - 0.01mm	1.4%	4.45%	2.84%	
	0.001 - 0.005mm	1.14%	4.14%	2.91%	
Field density	Wet density (g/cm^3)	1.94	1.99	1.96	N=7
	Dry density (g/cm^3)	1.71	1.77	1.73	

b) Mechanical soil test

Item \ Result		Min.	Max.	Average	No. of samples
Compaction test	Wopt (%)	11.8%	13.2%	12.4%	N=7
	ρdmax (g/cm^3)	1.80	1.85	1.82	
Shear strength	Friction angle (°)	(by measuring slope angles)		26°28' (25°27')	
	Cohesion(kg/cm^2)			0.05 - 0.07 (0.04 - 0.06)	

(3) Reservoir planning

i) Reservoir plan

Item	Unit	Size / Level
Total capacity of the reservoir	million m^3	228.0
Available capacity of the reservoir	million m^3	222.0
Full water level	m	EL. 1,320.5
Dead water level	m	EL. 1,284.5
Full water surface area	ha	1,010
Length of the reservoir	km	3.3
Useful water supply	million m^3	218.0

ii) Quantity of works

No.	Activity	Unit	Quantity	Review
Alternative 1				
1	Constructing clay coverage on the reservoir basin :1,750,000m^2×1.5m	million m^3	2.625	Transportation 3.5km warehouse
2	Setup of clay screen :Dam No.2	million m^3	0.983	ditto
3	Protective layer made of rocky soils: Dam No.2	million m^3	0.749	ditto
4	Dike (Dam) construction: Dam No.2	million m^3	0.938	ditto
5	Setup of clay screen :Dam No.1	million m^3	0.365	ditto
6	Protective layer made of rocky soils: Dam No.1	million m^3	0.274	ditto
7	Dike (Dam) construction: Dam No.1	million m^3	1.313	ditto
8	Protective layer of clay coverage: t=0.5m	million m^3	0.875	ditto
Alternative 2				
1	Preparatory coating of clay designed to lay the mastic compound: T=30cm	million m^3	0.525	Transportation 3.5km warehouse
2	Laying anti-filtration mastic compound	m^2	1,750,000	1,600 AMD / m^2
3	Clay-and-sand protective layer on the mastic compound: T=30cm	million m^3	0.525	Transportation 3.5km warehouse
4	Setup of clay screen :Dam No.2	million m^3	0.983	ditto
5	Protective layer made of rocky soils: Dam No.2	million m^3	0.749	ditto
6	Dike (Dam) construction: Dam No.2	million m^3	0.938	ditto
7	Setup of clay screen :Dam No.1	million m^3	0.365	ditto
8	Protective layer made of rocky soils: Dam No.1	million m^3	0.274	ditto
9	Dike (Dam) construction: Dam No.1	million m^3	1.313	ditto

(4) Dam design

i) Dam type and its dimensions

Item	Dam No.1	Dam No.2
Dam type	Zoned fill dam with inclined impervious core	
Dam crest level	EL. 1322.0m	EL. 1322.0m
Maximum dam height	48.0m	24.0m
Dam crest length	1130m	2810m
Dam crest width	9.0m	9.0m
Upstream slope inclination	1 : 3.5	1: 3.5
Downstream slope inclination	1 : 2.75	1 : 2.75
Total embankment volume	1,952,000m^3	2,670,000m^3

ii) Design values

Zone	Unit weight (t/m3)			Shear strength			
	ρd	ρt	ρsat	C^1 (t/m^2)	φ^1 (°)	C^2 (t/m^2)	φ^2(°)
Core zone	0.941	1.87	2.68	2.9	17°55'	2.8	17°15'
Sand-&-gravel	1.15	2.04	2.73	0.6	26°00'	0.5	24°20'
Stone blanket	1.19	1.95	2.75	0.0	38°00'	0.0	36°00'
Foundation	0.83	1.75	2.56	0.0	65°00'	0.0	60°00'

*ρd; dry density, ρt; wet density, ρsat; saturated density, C^1, φ^1; applied to unsaturated zones, C^2, φ^2; applied to saturated zones

iii) Stability analysis

Analysis method; Static seismic stability analysis (sliding-circle ~ slice-cut method)

Calculation; by computer

Summary of safety factors analyzed to Dam No.1 (Seismic intensity 8)

Reservoir water level	Adopted horizontal acceleration (gal)	Upstream side / downstream side	Minimum safety factor
Full water surface	Full combination of forces	upstream	1.772
	Mountains of seismic influence		1.088
	Components of seismic influence		1.080
1/3 water level to full water	Full combination of forces	upstream	1.513
	Mountains of seismic influence		1.069
	Components of seismic influence		1.064
—	Full combination of forces	downstream	1.457
	Mountains of seismic influence		1.112
	Components of seismic influence		1.107

1-2 Review of quake resistant design on the dam cross-section in 1989 after Spitak Earthquake

(1) Outline of the review study

Item	Content
Title of the report	Research Justification of the Earth Soil Dam Structures for the Hydro-Engineering Systems of Kaps and Yeghvard, Armenian SSR
Executed institution	All-Union Research Institute of Water Supply, Sewerage, Hydro-Engineering Structures and Engineering Hydrogeology (VNII VODGEO)
Section	Moscow Laboratory of Earth Soil Material Dams
Contract date	Third (3) of March, 1989
Background and purpose	- Review of the seismic intensity from 8 to 9 due to 1988 Spitak Earthquake - To enhance the quake resistant ability of the dam body

(2) Contents of the study and analysis

Item	Contents
Review of the shear strength to the sandy clay soils	Execution of soil tests to sandy clay soils. The design shear strength was re-estimated from φ=17’15”, C=0.028Mpa to φ=22’00”, C=0.039Mpa.(values applied to the saturated zones)
Review of the shear strength to the sand-and-gravel materials	Execution of the tri-axial compression test to the specimens with the diameter φ=215mm and height H=430mm. The design shear strength was re-estimated from φ=24’20”, C=0.005Mpa toφ=41’00” (embankment 0~20m) and φ=39’00” (embankment 20~45m).(values applied to the saturated zones, C; not counted)
Dynamic response analysis	Model experiments were executed on the stabilometer using the Universal test machine TS-D 10-0-PU. Followings were confirmed on the sand-and-gravel materials. - There is no risk of liquefaction phenomenon arising. - The dam crest might settle down by 53 cm in maximum. - Rocks might be crushed locally on the upstream slope protection. - The decline of shear strength does not occur in the sand-and-gravel zone. Followings were also confirmed regarding the sandy soil layer (Layer N 7) in the basement of Dam No.1 - There is no risk of liquefaction phenomenon arising. - Settlement ranging from 10 cm to 26 cm in maximum might occur.
Stability analysis (original design with the dam height of 45 m)	Static seismic method ~ sliding circle, slice-cut method was applied. The horizontal acceleration corresponding to seismic intensity 9 was evaluated by using the reduction coefficients shown in the quake resistant standard. Followings were confirmed and recommended. - The inclination of the upstream slope shall be changed from 1:3.50 gradient to 1:4.50 gradient. (the minimum safety factor; 1.09>1.08, OK) - The downstream slope shall be provided with the berm of 6 m wide at the elevation EL. 1302.0 m.

1-3 Present reservoir plan studied as F/S in 1999

(1) Reservoir plan

Item	Unit	Size / Level
Total capacity of the reservoir	million m^3	90.0
Available capacity of the reservoir	million m^3	84.0
Full water level	m	EL. 1,304.5
Dead water level	m	EL. 1,284.5
Full water surface area	ha	825
Length of the reservoir	km	3.2
Useful water supply	million m^3	80.8

(2) Dam type and its dimensions

Item	Dam No.1	Dam No.2
Dam type	Zoned fill dam with inclined impervious core	
Dam crest level	EL. 1306.0m	EL. 1306.0m
Maximum dam height	32.0m	14.0m
Dam crest length	1130.0m	2810.0m
Dam crest width	10.0m	10.0m
Upstream slope inclination	1 : 4.5	1: 4.5
Downstream slope inclination	1 : 2.75	1 : 2.75
Total embankment volume	1,860,000m^3	2,100,000m^3

(3) Quantity of works

No.	Activity	Unit	Quantity	Review
Alternative 1				
1	Earth blanket on the reservoir bottom :4,250,000m^2×1.5m	million m^3	6.375	Transportation 3.5km warehouse
2	Inclined core zone for facing :Dam No.2	million m^3	2.0	ditto
3	Rock protection on the embankment slope : Dam No.2	million m^3	0.378	ditto
4	Sand-and-gravel zone : Dam No.2	million m^3	1.8	ditto
5	Inclined core zone for facing :Dam No.1	million m^3	0.295	ditto
6	Rock protection on the embankment slope: Dam No.1	million m^3	0.390	ditto
7	Sand-and-gravel zone: Dam No.1	million m^3	2.125	ditto
Alternative 2				
1	Foundation arrangement on the reservoir bottom : T=30cm	million m^3	1.275	Transportation 3.5km warehouse
2	Laying of the anti-leakage sheet coating	m^2	4,250,000	1,600 AMD / m^2
3	Protection layer on the anti-leakage coating: T=30cm	million m^3	1.275	Transportation 3.5km warehouse
4	Inclined core zone for facing :Dam No.2	million m^3	2.0	ditto
5	Rock protection on the embankment slope: Dam No.2	million m^3	0.378	ditto
	Sand-and-gravel zone: Dam No.2	million m^3	1.800	ditto
8	Inclined core zone for facing :Dam No.1	million m^3	0.295	ditto
9	Rock protection on the embankment slope: Dam No.1	million m^3	0.390	ditto

(4) Existing embankment, quantity and construction specifications

Embankment	Zone / material	Embankment volume (m^3)
Dam No.1	Sand-and-gravel	Approximately 960,000
Dam No.2	Sand-and-gravel	Approximately 890,000

(5) Specification of construction

Item		Contents
Quality control criteria	Embankment density	2.0~2.1 t/m3 in wet density
	Grain size	
	Rock quality	
Frequency of control test	Embankment density	
	Grain size	
	Rock quality	
Specifications of construction works	Compaction machine	Vibratory roller
	Spreading machine	Bulldozer
	Compaction passing times	
	Layer's thickness before compaction	45 cm
	Arrangement of moisture content	spraying

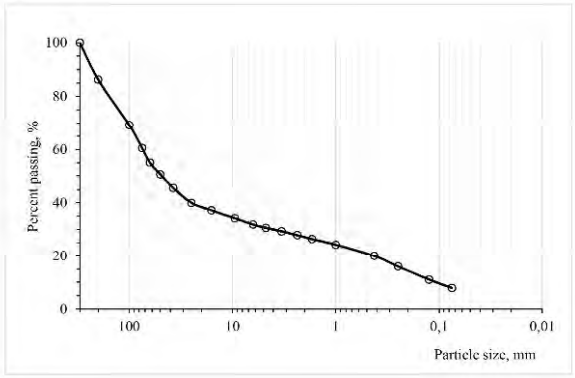
2. Laboratory tests of the embankment materials

2-1 Existing embankment

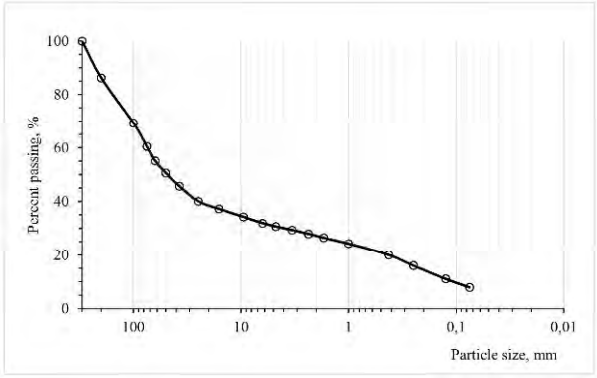
(1) Field moisture content Wf (to the grain size range less than 37.5mm)

The test results are Wf=5.97%, 7.04% ; the moisture content condition is not completely dry but dry side from the optimum moisture content by about 7%.

(2) Gradational condition



TP-1



TP-4

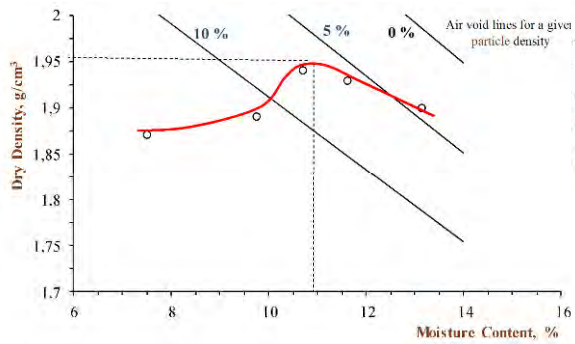
The portion of gradational curve ranging from about 1mm to about 20mm is gently inclined; comparing to this portion, the inclination of gradational curve more than 20mm is steep. This means the gradational contents between 1mm to 20mm are small relatively to the coarse portion more than 20mm.

The content percentage less than 0.075mm is low enough and the particle sizes are well distributed in the particle range less than 50mm/60mm so that it would be able to produce high quality filter materials by screening/sieving the original sand-and-gravels through 50mm/60mm slit.

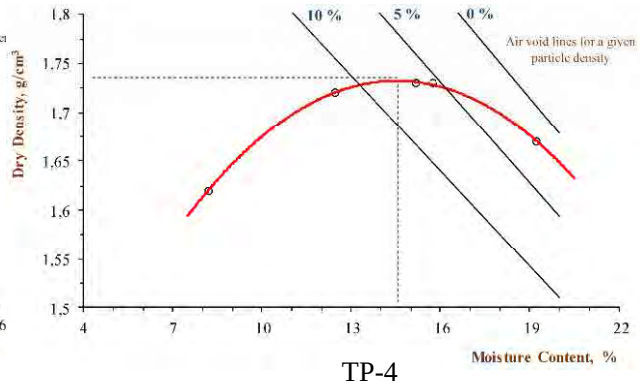
(3) Rock quality

The value of water absorption is lower than 2% (TP-1; 1.87%, TP-4; 1.67%) so that the rocks in sand-and-gravels are regarded as fresh and not weathered.

(4) Compaction degree of the embankment



TP-1



TP-4

The maximum dry densities of the compaction test carried out to the fine portion less than 37.5mm are TP-1; 1.94 t/m^3, TP-4; 1.73 t/m^3. On the other hand, the field density values regarding the fine portion

less than 37.5mm are TP-1; 2.00/(1+0.0597)=1.89 t/m^3, TP-4; 1.82/(1+0.0704)=1.70 t/m^3. These field densities correspond respectively to TP-1; 1.89/1.94=0.97 (97%), TP-4; 1.70/1.73=0.98 (98%) of the maximum density in the compaction test.

The above mentioned gradational conditions suggest that the embankment is built up by the framework structure of hard gravels/cobbles and the fine portion of the materials is difficult to receive compaction energy from the compactor due to the interference of energy transfer by gravels/cobbles. Considering such point, the relative density of 97% or 98% to the portion mainly composed of fine particles is regarded to show the well-compacted condition of the embankment.

2-2 Investigation of impervious materials

(1) Test-pit excavation

i) TP-2 (1.2 km from Dam No.1, beside the paved road)

Depth	Color	Gradation	Plasticity / adhesion	Remarks
	dark greyish brown	sandy clay		top-soil 40cm thick
0.5m				
1.0m				Coarse sand is contained.
1.5m				
2.0m				
	light yellowish brown	sandy clay	low plasticity low adhesion	Soil layer is dried-up and
2.5m				
3.0m				Soil becomes wet a little bit at
3.5m				around 3m in depth.
4.0m				

ii) TP-3 (300 from Dam No.1, on the top of gentle hill)

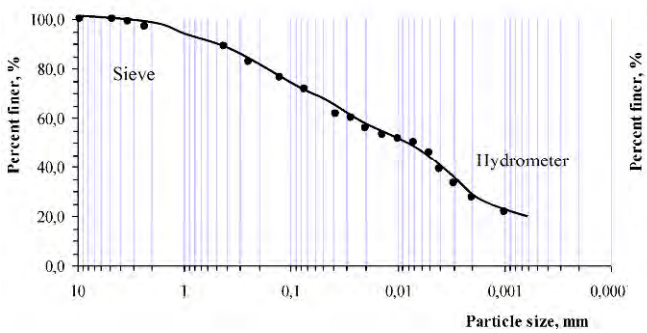
Depth	Color	Gradation	Plasticity/ adhesion	Remarks
0.5m	dark greyish brown	sandy clay no gravel		top-soil 40cm thick
1.0m			low plasticity low adhesion	Soil layer is dried-up and hard.
1.5m	light yellowish brown	sandy clay with rounded gravels		
2.0m				
2.5m	dark grey ～black			Black color was from burning
3.0m		sand-and-gravel with rounded pumises	non-plastic	deposit of volcanic and pumis by water in a short
3.5m	light brown			
4.0m				

(2) Laboratory test

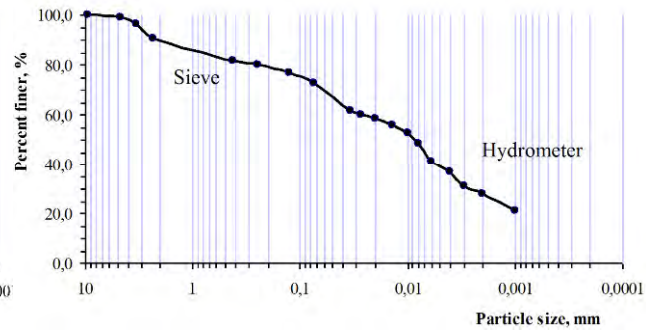
i) Field moisture content

In TP-3 the field moisture content of the upper layer is 10%, then 14.05% in the mid, 15.27% at the bottom, which shows the tendency of increase toward the bottom. In TP-2 9.43%, 6.07% and 8.33%; the latter two correspond to the pumice layer or volcanic sand.

ii) Gradational condition



TP-2（Lower）



TP-3（Upper）

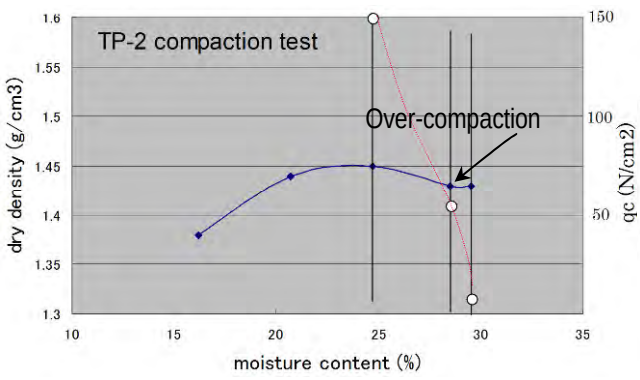
In case of TP-3, the percentage of silt and clay increases from 32.14% at the upper to 86.52% at the bottom. Gravels of which particle size is larger than 4.76mm are scarcely included from the upper to the lower.

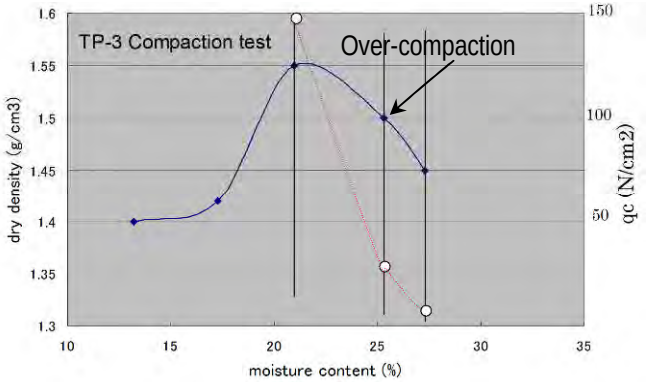
In case of the TP-2's surface layer, the percentage of silt and clay is 72.45% as same as TP-3 middle/lower. In case of the volcanic sand and pumice layer, its percentage is 11.09% to 15.69%; the main portion is composed of sand-and-gravel.

iii) Specific gravity

In case of TP-2, the values of specific gravity test results range from 2.55 to 2.61, which are the values of ordinary soils. In case of TP-3's volcanic sands, the value of specific gravity is 2.71 which is a bit different from usual soils.

iv) Compaction test and cone penetration test





The maximum dry density ranges from 1.45 g/cm^3 (TP-2) to 1.55 g/cm^3 (TP-3) and the W_{opt} (optimum

moisture content) from 24.0% (TP-2) to 21.1% (TP-3). The over-compaction phenomenon is observed at about 5% wet side from the W_{opt} and the q_c (cone penetration index) becomes very low on the wet side of the compaction curve. Considering the limit value of q_c for the heavy equipments to be workable being 60 N/cm^2, the workable region of moisture content would be 3% or so from W_{opt} so that very careful attitudes/processing would be required in the arrangement work of moisture content.

3. Anti-infiltration countermeasure to the reservoir bottom

3-1 Summary of borehole permeability tests in the past

Permeability test results to the reservoir basement

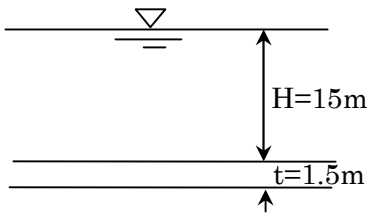
	Formations	Permeability Coefficient	
1	Recent Loamy sand, loam ($vdpQ_{IV}$)	1.97×10^{-4}	cm/sec
2	Sand and gravel/pebble (paQ_{IV})	5.03×10^{-3}	cm/sec
3	Recent Eluvial, Deluvial formation ($_{ed}Q_{IV}$)	1.63×10^{-3}	cm/sec
4	Late Quaternary Tuffs (βQ_{III})	4.68×10^{-3}	cm/sec
5	Middle Qua. Andecite lava (βQ_{II})	8.04×10^{-3}	cm/sec
6	Early Qua. Lap-ap-lap Q_{IV}	1.16×10^{-5}	cm/sec
7	Early Qua. Alluvial/proluvial sediments	3.08×10^{-3}	cm/sec
8	Layers of N 8,9,10	3.24×10^{-4}	cm/sec
9	Pumices ($_{\beta}Q_{I}$)	1.57×10^{-2}	cm/sec
10	Andecite/Scoria ($_{\beta}N_2$)	9.83×10^{-3}	cm/sec
11	Andecite layer (N_1)	2.83×10^{-3}	cm/sec
	Average (simple)	4.67×10^{-3}	cm/sec

3-2 Studying of anti-infiltration countermeasures

(1) Earth blanket coating method

In this method, the downward infiltration is constrained by the impervious coating of earth blanket which is formed through the process of spreading and compaction of clayey soil layers on the reservoir bottom. In case of the Yeghvard Reservoir, the sandy clay deposited in the reservoir basin is available for the impervious soil materials for earth blanket.

Under the assumption that the thickness of earth blanket t is 1.5 m, the water head against the upper surface of blanket H is 15 m, and the vertical permeability coefficient of earth blanket k is 5×10^{-6} cm/sec, the downward infiltration quantity through earth blanket is estimated by the formula "q=k x i x A".



Here, q; downward infiltration quantity per unit area (m^3/day)
k; vertical permeability coefficient $k=5\times10^{-6}$ cm/sec$=4.3\times10^{-3}$ m/day
i; hydraulic gradient i=H/t=15.0/1.5=10.0
A; unit area of seeping path A=1.0 m^2

Then; $q=4.3\times10^{-3}$m/day$\times10.0\times1.0=4.3\times10^{-2}$ m^3/day

Total infiltration quantity (Q) seeping out through the reservoir bottom of 600 ha (6,000,000 m^2);

$Q=4.3\times10^{-2}$ m^3/day$\times$6,000,000 m^2=258,000 m^3/day

This volume reaches about 6 times of the allowable infiltration quantity "q_a=90,000,000 $m^3\times0.0005$=45,000 m^3" which corresponds to 0.05 % of the total reservoir capacity; and 0.05 % is treated

in Japan as the criteria of allowable infiltration quantity (q_a) to the reservoir of irrigation use. Providing with three times of thickness is one of the ways to make the earth blanket be functional; but this is not practical from the view point of economy and possibility. Thus the earth blanket coating method is denied from the alternatives for anti-infiltration countermeasures.

(2) Watertight asphalt concrete coating method

i) Outline and past records

In this method, the reservoir bottom is paved and coated by watertight asphalt concrete through the in-situ construction works. The seepage control method by watertight asphalt concrete has a long history as the one for the facing of fill-type dam and has been chalking up the track record also for the waste repository in recent years. The permeability coefficient of the watertight asphalt concrete is estimated to be less than $k=1\times10^{-8}$ cm/sec and this work is regarded to have shutoff function against seepage flow.

ii) Self-holding ability against seismic movements

Self-holding abilities of this material against seismic movements are considered to be high enough based on the track record achieved as the facings of fill-type dams in Japan.

iii) Foundation works

Homogeneous and tough enough foundation works must be provided so that asphalt pavement works can be performed there by the heavy equipment compaction. The area and the level required for the foundation works are not clear at this stage because of the reservoir bottom being composed of many kinds of volcanic sediments. In addition, some treatment shall be required at the edge of works overlapping to the sandy clay sediment area.

iv) Protection works

Protection works to the pavement surface are not required especially because of the checking on foot and equipment works being allowable there. But it would be desirable for the pavement to be kept under water all through a year, especially as the anti-frozen measure in winter.

v) Repair

Damaged portions can be found by the movement of floats on the water surface; and then can be repaired if necessary.

vi) Approximate construction cost (based on the quantity survey in other project)

Single structure with 3 layers - total thickness 16 cm; 1 set ¥15,000/m^2 (150 USD/ m^2)

(3) Coating method by low density polyethylene sheet or rubber sheet

i) Outline and past records

In this method, the infiltration through the reservoir bottom is prevented by the watertight sheet made of polyethylene or rubber covering its bottom surface. It is long since the low density polyethylene sheet or the rubber sheet has been being used as the seepage control work for irrigation-use reservoirs; but its history has many failures together with many successes so that it is important to conduct the design

considering how to avoid the damage due to faulty workmanship and to carry out the careful construction works. In these days, this method has been chalking up the track record as the seepage control for the waste repository; and such demand has brought the production of large size such as 5 m to 8 m in width and 50 m to 200 m in length. It is said that the permeability of the material is less than $k=1\times10^{-12}$ cm/sec so that the downward infiltration is avoided completely if faulty workmanship could be avoided completely.

ii) Self-holding ability against seismic movements

Self-holding ability against seismic movements is secured because of its high stretch properties.

iii) Foundation works

Foundation works shall be needed as the sheet is easily damaged by sharp edged gravels on the ground. Considering the site conditions, approximately 30 cm thick sandy clay of spreading/compaction shall be provided as the foundation arrangement.

iv) Protection works

The sheets might be damaged by workers' walking around on their surface, by the deteriorating action of ultraviolet rays, and by the moves of ice blocks in winter, so that the sheets' surface shall be protected by a suitable protection cover. Considering the site conditions, approximately 50 cm thick sandy clay of spreading/compaction shall be provided as the protection cover.

v) Repair

Damaged portions can be found by the movement of floats on the water surface; and then can be repaired if necessary.

vi) Approximate construction cost

Foundation (t=30cm) + laying of sheet (t=1.5mm) + protection (t=50cm)

=¥300/m^2 + {¥3,440/m^2 (sheet price) +¥ 300/m^2 (transportation - laying)} + ¥500/m^2

=¥4,540/m^2 (45 USD/ m^2)

(4) Coating method by bentonite sheet

i) Outline and past records

In this method, the infiltration through the reservoir bottom is prevented by the watertight bentonite sheet covering its bottom surface. Bentonite sheets have a lot of track record as the seepage control work for irrigation-use reservoirs; but news/information regarding their performances are sometimes positive and sometimes negative, so that it is important in the design/construction to examine the site conditions under which the materials are laid, to conduct careful construction works, and to consider how to avoid the damage due to faulty workmanship. As an example, the production size of the sheet is 6 mm thick, 2.4 m wide and 25 m long, which suggests that the laying works of sheets in wide area are carried out by plenty times of jointing works by manpower ant that the problem is how to avoid human errors in these jointing works.

It is said that the permeability of the material is less than $k=1\times10^{-9}$ cm/sec so that the downward infiltration is avoided almost completely if faulty workmanship could be avoided completely.

ii) Self-holding ability following seismic movements

Self-holding ability against seismic movements is secured because of its high stretch properties.

iii) Foundation works

Foundation works shall be needed as the sheet is easily damaged by sharp edged gravels on the ground. Considering the site conditions, approximately 30 cm thick sandy clay of spreading/compaction shall be provided as the foundation arrangement.

iv) Protection works

The sheets might be damaged by workers' walking around on their surface, by the deteriorating action of ultraviolet rays, and by the moves of ice blocks in winter, so that the sheets' surface shall have to be protected by a suitable protection cover. Considering the site conditions, approximately 50 cm thick sandy clay of spreading/compaction shall be provided as the protection cover.

v) Repair

Damaged portions can be found by the movement of floats on the water surface; and then can be repaired if necessary.

vi) Approximate construction cost

Foundation (t=30cm) + laying of sheet (t=6mm) + protection (t=50cm)

=¥300/m^2 + {¥3,200/m^2 (sheet price) +¥ 400/m^2 (transportation - laying)} + ¥500/m^2

=¥4,400/m^2 (44 USD/ m^2)

(5) Soil-cement coating method

i) Outline and past records

In this method, the downward infiltration is constrained by the impervious coating of soil-cement constructed on the reservoir bottom. Soil cement has a long history of being used empirically for small-scale waterway constructions, ground improvement works; and recent years, the soil cement technology called "Sabo Soil Cement" for large scale civil structures such as dams, dikes or retaining walls have established in Japan. But soil cement including Sabo Soil Cement has rare example of being used as an anti- infiltration work to wide area with a focus on its impervious property. But in this case, applying the soil-cement coating method shall suggest big advantages as follows.

- The soil-cement layer shall be easily provided on the reservoir bottom through the process of mixing soils obtained in the site with cement powder, spreading the mixed soils on the ground and compacting its layer by a compactor.
- The soil-cement layer shall work as anti- infiltration coating due to its impervious property because mixing cement might accelerate the impervious characteristic of sandy clay soils.

- The soil-cement coating works shall be carried out in a big scale by heavy equipments for earth works so that the problem of human error would not appear here.

The permeability coefficient soil-cement would be $k=5\times10^{-8}$ cm/sec or so considering the one of concrete, but it is necessary to be confirmed in the field test. And it shall be confirmed if some hazardous chemical such as hexavalent chromium liquate comes out.

ii) Self-holding ability following seismic movements

The self-holding ability is low because of its relatively high rigidity. It might be possible for the layer to be destroyed by tension/compression brought from the phase shifting of seismic waves. To provide the layer with masonry joints for inducing cracks shall be effective to limit the damaged parts and make the repair works easy.

iii) Foundation works

Usually foundation works shall not be required; exceptionally in case of the foundation being composed of soft sedimentations, replacement shall be needed.

iv) Protection works

It is desirable for the soil-cement layer to be kept under water to avoid the cracks due to temperature alteration.

v) Repair

Damaged portions can be found by the movement of floats on the water surface; and then can be repaired if necessary.

vi) Approximate construction cost (per m^2 ; 30 cm×2 layers＝$0.6m^3$)

Mixing of soil-cement (cement $80kg/m^3$ + mixing) + compaction (t=30cm×2layers)

= (¥13,000×1/1,000kg×$80kg/m^3$ + ¥200/m^3 +¥1,000/m^3)×0.6 m^3/m^2

=¥1,344/m^2 (13.4 USD/ m^2)

(6) Imperviousness-strengthened earth blanket coverage method

i) Outline and past records

The reservoir bottom is covered with the earth blanket layer of which imperviousness is strengthened by mixing bentonite powder with sandy clay soil or by producing a thin mat of bentonite powder between the layers of sandy clay soil. There is no information of such method being applied but a lot of information of bentonite being used as an anti-infiltration material; and this method is considered as the modified one from the bentonite sheet method aiming to advance the economy and the construction reliability/performance of the former one.

ii) Self-holding ability following seismic movements

The self-holding ability is high because of the low rigidity of bentonite and earth blanket.

iii) Foundation works

Usually foundation works shall not be required except the case of the foundation being composed of a

coarse gravelly layer or so.

iv) Protection works

Protection works shall not be required as the top soil layer works as the protection.

v) Repair

Damaged portions shall be found by the movement of floats on the water surface; and then shall be repaired if necessary.

vi) Approximate construction cost

Spreading and compaction; per m^2: 30 cm×3 layers=0.9m^3

Two layers, each 1 cm thick, are sandwiched among 3 soil layers

Spreading/compaction(t=30cm×3layers) + bentonite powder (t=1cm×2layers + work fee50%

=¥1,000/m^3×0.9 m^3/m^2+¥30,000/1,000kg×25kg/bag×1bag/25ℓ×10ℓ/m^2/layer×2layer×1.5

=¥1,800/m^2 (18 USD/ m^2)

Preliminary Cost Estimate -Yeghvard Reservoir (Irrigation Project)-

As of March 2013

1 USD=415AMD

No.	Component	Main works	Estimated cost		
			'000 AMD	'000 USD	%
N1	Reservoir basin	Polyethlene sheet instllation; 10 million m2 (Appr. 3km x 3km) Clay-sand, alumina transferring, loading and laying; 7.5 million tons Gravel transferring, loading and laying; 5.4 million tons	32,201,555	77,594	72%
N2	Dam No.1	Clay-sand, alumina demolition and transferring; 1.5 million tons Creating clay screen; 861 m3 Gravel transferring, loading and laying; 0.8 million tons	4,354,336	10,492	10%
N3	Dam No.2	Clay-sand, alumina demolition and transferring; 1.2 million tons Creating clay screen; 672 m3 Gravel transferring, loading and laying; 0.8 million tons	3,887,198	9,367	9%
N4	Irrigation outlet from Dam No.1-->Kasakh River	Concrete work; 5,600 m3 Re-bar instllation; 336 tons Metal pipe (D=1.6m) instllation; 160m	575,971	1,388	1%
N5	Irrigation outlet from Dam No.2-->Arzni Branch area Feeding pipeline 1, Simultaneously outlet 2 (DM 129+57; 12.957 km)	Concrete work; 2,000 m3 Re-bar instllation; 120 tons Metal pipe (D=1.4m) instllation; 148m	309,570	746	1%
N6	Embankment (Serving as the reservoir shore protection structure)	Removing and transferring humus (surface soil); 74,400 tons Grassing and watering; 76,000 m2	162,198	391	0%
N7	Feeding canal (1) Arzni-Shamiram to the Reservoir	Removing and transferring humus (surface soil); 1.4 m3 Backfilling clay-sand by hand; 400 m3 GRP pipe D=0.6 m; 1,100 m3	46,875	113	0%
N8	Feeding canal (2) Arzni-Shamiram to the Reservoir	Removing and transferring humus (surface soil); 74 m3 Backfilling clay-sand by hand; 20,000 m3 GRP pipe D=2.6 m; 3,700 m3	1,882,440	4,536	4%
N9	Rehabilitation of Arzni-Shamiram canal	Detonation; 10,000 m3, Filling gravel, sand; 10,000 m3 Concrete work (including demolition canal, insallation); 15,000 m3 Re-bar installation; 450 tons	1,122,133	2,704	3%
N10	**Sub-total**		**44,542,276**	**107,331**	**100%**
	Value added Tax	(20%)	8,908,455	21,466	
	Total		**53,450,731**	**128,797**	

Added Items

	Sub-total of N4,N5,N6,N7,N8,N9 (Canal development)	4,099,187		
N11	**Improvement of Kasakh Intake;**	**Tentative 50% of canal development??**	**2,049,593**	**4,939**
N12	**Improvement of Secondary / Tertiary canals;**	**Tentative 50% of canal development??**	**2,049,593**	**4,939**
N13	**Sub-total (N10+N11+N12)**		**48,641,462**	**117,208**
N14	Price escalation (in 2013)	5%	2,432,073	5,860
N15	**Sub-total (N13+N14)**		**51,073,535**	**123,069**
N16	Consultant fee (Enginering & Construction supervision)	10%	5,107,354	12,307
N17	**Sub-total (N15+N16)**		**56,180,889**	**135,376**
N18	Physical contingencies (Kaps)	15%	8,427,133	20,306
N19	Finacial contingencies (Kaps)	4%	2,247,236	5,415
N20	**Total (N17+N18+N19)**		**66,855,258**	**161,097**
N21	Value added Tax	(20%)	13,371,052	32,219
	Grand Total		**80,226,310**	**193,316**

Reservoir Basin (N1)

Appendix F-2

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials				
										Items	Cost	Price Unit	Price Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	1-144	I class clay sand/ alumina loading by excavator 2.5m3	1000m3	1,500	3.240	55.920	**237,653**	7,990	229,663					0.16
2	310-1	Transfer of clay sand/ alumina by dump tracks 1km	ton	2,475,000		0.270	**1,829,669**	0	1,829,669					0.74
3	42-7	Preparation layer out of clay sand/alumina b-30sm	100m3	15,000	4.230	8.650	**459,567**	104,312	355,256					0.31
4	42-72	Installation of polyethylene layer	m2	10,000,000	0.019	0.005	**11,853,784**	312,360	131,424	Polyethylene layer m2	1	1	11,410,000	1.19
5	1-144	I class clay sand/ alumina loading by excavator 2.5m3	1000m3	3,000	3.240	55.920	**475,307**	15,980	459,327					0.16
6	310-1	Transfer of clay sand/ alumina by dump tracks 1km	ton	4,950,000		0.270	**3,659,337**	0	3,659,337					0.74
7	42-7	Protection layer out of clay sand/ alumina	100m3	30,000	4.230	8.650	**919,135**	208,624	710,511					0.31
8	.1-147	IV class gravel-pebble soil loading by excavator 2.5m3 dumping	1000m3	3,000	6.610	113.050	**961,193**	32,601	928,593					0.32
9	310-1	Transfer by dump tracks 1km	ton	5,400,000		0.270	**3,992,004**	0	3,992,004					0.74
10	42-7	gravel-pebble layer installation b-30sm	100m3	30,000	4.230	8.650	**919,135**	208,624	710,511					0.31
10	1-1150	Compaction of road padding by the roller 25 t 4 transition	100m3	15,000		7.260	**298,168**	0	298,168					0.20
		Sub-total (1)					**25,604,951**	**890,489**	**13,304,462**				**11,410,000**	
		Tax 13.3%	13.3%				**3,405,459**							
		Sub-total (2)					**29,010,410**							
		Profit (Overhead) 11%	11.0%				**3,191,145**							
		Total					**32,201,555**							

Dam No.1 (N2)

Appendix F-3

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials		Price		
										Items	Cost	Unit	Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	.1-28	Class IV soil demolition by excavator 2.5m3, rib padding/filling	1000m3	127	5.630	96.370	34,735	1,177	33,558					0.27
2	.1-144	I class humus loading by excavator 2.5m3	1000m3	18	3.240	55.920	2,890	97	2,793					0.16
3	310-5	Transfer of humus by dump tracks 5km	ton	21,890		0.500	29,967	0	29,967					1.37
4	.1-144	I class humus demolition by excavator í 2.5m3 loading (clay sand/alumina)	1000m3	913	3.240	55.920	144,604	4,862	139,743					0.16
5	310-2	Transfer by dump tracks 2km	ton	1,505,900		0.330	1,360,641	0	1,360,641					0.90
6	.36-5	Creation of the screen of the dam out of clay sand/ alumina	1000m3	861	16.900	124.100	316,477	23,922	292,556					0.37
7	.1-28	Class IV soil demolition by excavator 2.5m3, rib padding/filling	1000m3	214	5.630	96.370	58,502	1,983	56,519					0.27
8		Pestling, sorting machine with a capacity of 125m3/h	machine/hr	1,714		1.270	5,960	0	5,960					3.48
9	1-236	Transfer of the leftover of IV class soil in the result of sorting, leveling by a bulldozer	1000m3	107		185.600	54,374	0	54,374					0.51
10	.1-147	Loading of the leftover of IV class soil in the result of sorting, dumping 2.5m3,	1000m3	107	6.610	113.050	34,283	1,163	33,120					0.32
11	310-3	Displacement 3 km	ton	182,000		0.390	194,343	0	194,343					1.07
12	38-7	Dam transition layer, filter	1000m3	105	6.710	47.950	14,943	1,158	13,785					0.14
13	.1-147	IV class soil demolition by excavator 2.5m3, loading, dumping	1000m3	408	6.610	113.050	130,722	4,434	126,289					0.32
14	310-2	Gravel-cobble transfer 2 km	ton	816,000		0.330	737,289	0	737,289					0.90
15	.36-2	Creation of the dam body out of pebble-gravel soil	1000m3	400	5.660	55.040	64,002	3,722	60,280					0.16
16	3--108	Explosion VII class	m3	51,000	0.085	0.270	83,351	7,127	37,702	Explosive materials kg	0.75	0.74	32296.01	1.63
										Electric Detonator item	0.002	0.19	22.11	
										Cable for Electric Detonator m	0.46	0.15	4015.18	
										Cable for explosion m	0.33	0.07	1344.21	
										Drilling bit item	0.0026	3.12	472.05	
										Pneumanic hammer item	0.001	3.2	186.21	
										Trammel drill item	0.001	3.2	186.21	
17	3--246	To brake large fragments into pieces through explosives	m3	51,000.0	0.005	0.0023	2,016	419	321	Explosive materials kg	0.004	0.74	172.25	0.04
										Electric Detonator item	0.072	0.19	796.05	
										Drilling bit item	0.00008	3.12	14.52	
										Cable for explosion m	0.072	0.07	293.28	
18	.1-149	VI class humus loading by excavator 2.5m3	1000m3	61.0	9.92	170.60	29,488	995	28,493					0.48
19	310-5	Transfer of the stones by dump tracks 5km	ton	107,000.0		0.50	146,483	0	146,483					1.37
20	42-1	To fix the repose of the dam with a stone	100m3	600.0	1.83	9.41	17,264	1,805	15,459					0.29
		Sub-total (1)					3,462,335	52,863	3,369,674				39798.08	
		Tax 13.3%	13.3%				**460,491**							
		Sub-total (2)					**3,922,826**							
		Profit (Overhead) 11%	11.0%				**431,511**							
		Total			**4,354,336**									

Dam No.2 (N3)

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials		Price		
										Items	Cost	Unit	Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	.1-28	Class IV soil demolition by excavator 2.5m3, rib padding/filling	1000m3	350	5.630	96.370	95,591	3,240	92,351					0.27
2	.1-144	I class humus loading by excavator 2.5m3	1000m3	30	3.240	55.920	4,816	162	4,655					0.16
3	310-5	Transfer of humus by dump tracks 5km	ton	36,480		0.500	49,941	0	49,941					1.37
4	.1-144	I class humus demolition by excavator í 2.5m3 loading (clay sand/alumina)	1000m3	712	3.240	55.920	112,790	3,792	108,998					0.16
5	310-2	Transfer by dump tracks 2km	ton	1,174,400		0.330	1,061,117	0	1,061,117					0.90
6	.36-5	Creation of the screen of the dam out of clay sand/ alumina	1000m3	672	16.900	124.100	246,823	18,657	228,166					0.37
7	.1-28	Class IV soil demolition by excavator 2.5m3, rib padding/filling	1000m3	204	5.630	96.370	55,716	1,888	53,828					0.27
8	¶Ý³62	Pestling, sorting machine with a capacity of 125m3/h	machine/hr	1,632		1.270	5,675	0	5,675					3.48
9	1-236	Transfer of the leftover of IV class soil in the result of sorting, leveling by a bulldozer	1000m3	102		185.600	51,834	0	51,834					0.51
10	.1-147	Loading of the leftover of IV class soil in the result of sorting, dumping 2.5m3,	1000m3	102	6.610	113.050	32,681	1,108	31,572					0.32
11	310-3	Displacement 3 km	ton	184,000		0.390	196,479	0	196,479					1.07
12	38-7	Dam transition layer, filter	1000m3	100	6.710	47.950	14,232	1,103	13,129					0.14
13	.1-147	IV class soil demolition by excavator 2.5m3, loading, dumping	1000m3	408	6.610	113.050	130,722	4,434	126,289					0.32
14	310-2	Gravel-cobble transfer 2 km	ton	816,000		0.330	737,289	0	737,289					0.90
15	.36-2	Creation of the dam body out of pebble-gravel soil	1000m3	400	5.660	55.040	64,002	3,722	60,280					0.16
16	3--108	Explosion VII class	m3	42,000	0.085	0.270	68,642	5,869	31,049	Explosive materials kg	0.750	0.740	26,597	1.63
										Electric Detonator item	0.002	0.190	18	
										Cable for Electric Detonator m	0.460	0.150	3,307	
										Cable for explosion m	0.330	0.070	1,107	
										Drilling bit item	0.003	3.120	389	
										Pneumanic hammer item	0.001	3.200	153	
										Trammel drill item	0.001	3.200	153	
17	3--246	To brake large fragments into pieces through explosives	m3	42,000	0.005	0.002	1,661	345	264	Explosive materials kg	0.004	0.740	142	0.04
										Electric Detonator item	0.072	0.190	656	
										Drilling bit item	0.000	3.120	12	
										Cable for explosion m	0.072	0.070	242	
18	.1-149	VI class humus loading by excavator 2.5m3	1000m3	51	9.920	170.600	24,654	832	23,822					0.48
19	310-5	Transfer of the stones by dump tracks 5km	ton	89,000		0.500	121,841	0	121,841					1.37
20	42-1	To fix the repose of the dam with a stone	100m3	500	1.830	9.410	14,387	1,504	12,882					0.29
		Sub-total (1)					3,090,891	46,656	3,011,461				32,775	
		Tax 13.3%	13.3%				**411,089**							
		Sub-total (2)					**3,501,980**							
		Profit (Overhead) 11%	11.0%				**385,218**							
		Total		**3,887,198**										

Irrigation outlet from Dam No.1-->Kasakh River (N4)

Appendix F-5

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials				
										Items	Cost	Price		
												Unit	Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	37-707	E/ Installation of concrete	m3	5,600	2.98	0.54	230,365	27,435	8,280	Concrete m3	1.015	23.890	154,937	41.14
										Cem. Mortar	0.026	29.200	4,851	
										mold/template m2	0.820	3.500	18,338	
										bolt kg	0.490	0.820	2,567	
										Timber m3	0.019	114.960	13,956	
2	37-727	Rebar Installation	ton	336	8.61	12.21	143,941	4,756	11,233	Rebar ton	1.000	333.750	127,952	428.39
3	.6-245	Cleaning of the surface of the concrete	m2	950	0.30	0.20	1,047	469	520	Sand m3	0.030	1.780	58	1.10
4	22-85	Metal pipe fitting d=1600x16mm	m	160	2.00	2.56	62,875	526	1,121	metal pipe m	1.000	335.380	61,227	392.97
5	22-362	Metal shaped parts	ton	8	190.00	162.00	10,155	2,499	3,548	metal shaped parts	1.000	450.000	4,108	1269.37
6	22-120-1	Flat valve installation	ton	12	54.20	72.10	9,600	1,069	2,369	flat valve ton	1.000	450.000	6,161	799.96
		Sub-total (1)					457,981	36,754	27,072				394,156	
		Tax 13.3%	13.3%				**60,911**							
		Sub-total (2)					**518,893**							
		Profit (Overhead) 11%	11.0%				**57,078**							
		Total				**575,971**								

Irrigation outlet from Dam No.2-->Arzni Branch area (N5)

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials				
										Items	Cost	Price		
												Unit	Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	37-707	E/ Installation of concrete	m3	2,000	2.98	0.54	82,273	9,798	2,957	Concrete m3	1.015	23.890	55,335	41.14
										Cem. Mortar	0.026	29.200	1,732	
										mold/template m2	0.820	3.500	6,549	
										bolt kg	0.490	0.820	917	
										Timber m3	0.019	114.960	4,984	
2	37-727	Rebar Installation	ton	120	8.61	12.21	51,407	1,699	4,012	Rebar ton	1.000	333.750	45,697	428.39
3	.7-36	Cleaning of the surface of the concrete	m3	760	12.20	7.40	55,963	15,243	15,399	Cem. Mortar	1.000	29.200	25,321	73.64
4	22-83	Metal pipe fitting d=1400x14mm	m3	148	1.79	2.22	44,734	436	900	metal pipe m	1.000	257.000	43,399	302.26
5	22-362	Metal shaped parts	ton	6	190.00	162.00	7,616	1,874	2,661	metal shaped parts	1.000	450.000	3,081	1,269.37
6	22-120-1	Flat valve installation	ton	5	54.20	72.10	4,160	463	1,027	flat valve t	1.000	450.000	2,670	799.96
		Sub-total (1)					246,154	29,513	26,955				189,686	
		Tax 13.3%	13.3%				**32,738**							
		Sub-total (2)					**278,892**							
		Profit (Overhead) 11%	11.0%				**30,678**							
		Total					**309,570**							

Embankment (N6)

Appendix F-7

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials				
										Items	Cost	Price		
												Unit	Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	.1-144	I class soil loading by excavator 2.5m3	1000m3	62	3.240	55.920	9,823	330	9,493					0.16
2	310-3	Transfer of humus 3km	ton	74,400		0.430	87,594	0	87,594					1.18
3	1-233	Spreading humus on the shep (repose) by bulldozer 30մ	1000m3	15		89.200	3,712	0	3,712					0.24
4	1-1205 1-1206	grass sow and watering	m2	76,000	0.007	0.096	23,241	875	19,976	Seed kg	0.027	1.000	2,341	0.31
								0	0	Water m3	0.004	0.141	49	
5	27-214	Warning concrete stands	item	265	0.350	0.750	4,600	152	544	Warning concrete stands item	1.000	12.910	3,904	17.36
		Sub-total (1)					128,971	1,357	121,320				6,294	
		Tax 13.3%	13.3%				**17,153**							
		Sub-total (2)					**146,124**							
		Profit (Overhead) 11%	11.0%				**16,074**							
		Total					**162,198**							

Feeding canal (1) Arzni-Shamiram to the Reservoir (N7)

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		**Estimated cost in '000 AMD**							1 ÙÇ³íáñÇ ³ñÅ
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials				
										Items	Cost	Price		
												Unit	Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	.1-28	IV class humus demolition by excavator 2.5 m3 rib padding	1000m3	1.350	5.630	96.370	369	12	356					0.27
2	1-968	Preparation layer from clay sand	m3	165.000	0.460		125	125	0					0.76
3	1-968	Backfilling of clay sand by hand	m3	400.000	0.460		302	302	0					0.76
4	1-261	Backfilling of mineral products from IV class humus by bulldozer	1000m3	0.600		22.100	36	0	36					0.06
5	1-236	Leveling of the soil by bulldozer	1000m3	0.350		69.200	66	0	66					0.19
6	22-124	GRP pipe d=600mm	m3	1,100.000	0.460	0.320	36,374	832	964	GRP pipe d=600mm	1.000	27.550	34,578	33.07
		Sub-total (1)					37,272	1,272	1,423				34,578	
		Tax 13.3%	13.3%				**4,957**							
		Sub-total (2)					**42,229**							
		Profit (Overhead) 11%	11.0%				**4,645**							
		Total				**46,875**								

Feeding canal (2) Arzni-Shamiram to the Reservoir (N8)

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials				
										Items	Cost	Price		
												Unit	Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	.1-28	Class IV soil demolition by excavator 2.5m3, rib padding/filling	1000m3	74	5.63	96.37	20,211	685	19,526					0.27
2	1-968	Preparation layer from clay sand/alumina	m3	2,200	0.46		1,664	1,664	0					0.76
3	1-968	Backfilling of clay sand/ alumina by hand	m3	20,000	0.46		15,125	15,125	0					0.76
4	1-261	Backfilling of mineral products from IV class soil by bulldozer	1000m3	30		22.10	1,815	0	1,815					0.06
5	1-236	Excessive soil leveling by bulldozer	1000m3	24		69.20	4,547	0	4,547					0.19
6	22-124	GRP pipe d=2600mm	m3	3,700	1.52	1.07	1,433,511	9,246	10,840	GRP pipe d=2600mm m	1.000	334.800	1,413,425	387.44
7	.39-5	Metal Structures	ton	30	54.9	22.30	19,943	2,708	1,832	Metal Structures	1.000	450.000	15,404	664.76
		Sub-total (1)					1,496,815	29,427	38,560				1,428,829	
		Tax 13.3%	13.3%				**199,076**							
		Sub-total (2)					**1,695,892**							
		Profit (Overhead) 11%	11.0%				**186,548**							
		Total				**1,882,440**								

Rehabilitation of Arzni-Shamiram Canal (N9)

No.	Soviet time no.	Works	Unit	Quantity	Based in 1984		Estimated cost in '000 AMD							Rate
					Main salary	Machinery operation	**Total**	Main salary	Machinery operation	Materials				
										Items	Cost	Price Unit	Price Total	
1	2	3	4	5	6	7	**8**	9	10	11	12	13	14	15
1	.1-28	Class IV soil demolition by excavator 2.5m3, rib padding/filling	1000m3	25	5.630	96.370	6,828	231	6,597					0.27
2	3--14	VII class detonation with 1-2m padding/filling	m3	10,000	0.130	0.260	15,558	2,137	7,119	Eplosives kg	0.400	0.740	3,377.36	1.56
										Electrodetonator item	0.520	0.190	1,127.31	
										Cable for detonator m	1.050	0.150	1,797.08	
										Drilling item	0.002	3.120	0.18	
3	3--246	To brake large fragments into pieces through explosives	m3	10,000	0.005	0.002	395	82	63	Explosive materials kg	0.004	0.740	33.77	0.04
										Electrodetonator item	0.072	0.190	156.09	
										Drilling item	0.000	3.120	2.85	
										Cable for explosion m	0.072	0.070	57.51	
4	.1-30	Class IV soil demolition by excavator 2.5m3, rib padding/filling	1000m3	10	7.880	134.120	3,802	130	3,672					0.38
5	1-970	Useful production from the IV class soils	m3	3,000	0.660		3,255	3,255	0					1.09
6	1-261 1-271	Useful production from the IV class soils by a bulldozer	1000m3	27		22.100	1,634	0	1,634					0.06
7	1-236	Creation of road padding by bulldozer out of IV class soils	1000m3	35		69.200	6,631	0	6,631					0.19
8	1-1150	Compaction of the road padding by rollers, 25 ton, with 4 transitions Ñ-35sm	100m3	350		6.260	5,999	0	5,999					0.17
9	1-989	Canal concrete demolition by jackhammer	m3	3,000	1.870	1.860	24,501	9,223	15,278					8.17
10	27-22-1	filling gravel and sand ground	m3	10,000	0.110	0.760	48,208	1,808	20,809	something like gravel and sand Ù3	1.260	1.780	25,590	4.82
11	37-74	Preparation layer out of concrete	m3	700	0.950	0.090	19,141	1,093	172	heavy concrete Ù3	1.015	22.050	17,876	27.34
12	37-707	Installation of the concrete	m3	8,000	2.980	0.540	329,093	39,193	11,828	concrete m3	1.015	23.890	221,339	41.14
										Cem. morter	0.026	29.200	6,930	
										mold m2	0.820	3.500	26,197	
										bolt kg	0.490	0.820	3,668	
										timber m3	0.019	114.960	19,938	
13	37-705	Canal from concrete	m3	6,800	1.020	0.530	215,662	11,403	9,868	Concrete m3	1.015	23.890	188,138	31.71
										Cem. Morter	0.007	29.200	1,563	
										morter m2	0.130	3.500	3,530	
										timber m3	0.001	114.960	1,160	
14	37-727	Rebar installation	ton	408	8.610	12.210	174,785	5,775	13,640	rebar ton	1.000	333.750	155,370	428.39
15	37-705	E / concrete pillar rebar consumption 150kg/m3	m3	225	1.020	0.530	7,167	377	327	heavy concrete m3	1.015	23.890	6,225	31.85
										cem. morter	0.007	29.200	52	
										mold 2	0.130	3.500	117	
										timber m3	0.001	114.960	70	
16	37-727	Rebar installation	ton	34	8.610	12.210	14,458	478	1,128	rebar ton	1.000	333.750	12,852	428.39
17	37-713	E/ Installation of precast concrete plates	m3	1,100	2.000	2.950	12,502	3,617	8,885				0	11.37
18	ÆÜü	E/ Value of precast concrete plates	item	244			2,642	0	0	cost of the plates item	1.000	9.490	2,642	10.83
		Sub-total (1)					892,260	78,803	113,649				699,808	
		Tax 13.3%	13.3%				**118,671**							
		Sub-total (2)					**1,010,931**							
		Profit (Overhead) 11%	11.0%				**111,202**							
		Total					**1,122,133**							

Financial Evaluation a)at Request Project cost=193 Million USD

	Year	Project Cost	Project Benefit				Benefit-Cost	Discount Rate (10%)	Discounted Cost	Discounted Benefit
			Crop	Livestock	O&M Reduction	(Total)				
0	2015							1.0000		
1	2016	38,660,000				0	-38,660,000	0.9000	34,794,000	0
2	2017	38,660,000				0	-38,660,000	0.8100	31,314,600	0
3	2018	38,660,000				0	-38,660,000	0.7290	28,183,140	0
4	2019	38,660,000				0	-38,660,000	0.6561	25,364,826	0
5	2020	38,660,000	8,362,273	1,613,120	1,750,000	11,725,393	-26,934,607	0.5905	22,828,343	6,923,727
6	2021		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.5314		6,231,355
7	2022		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4783		5,608,219
8	2023		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4305		5,047,397
9	2024		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3874		4,542,657
10	2025		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3487		4,088,392
11	2026		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3138		3,679,553
12	2027		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2824		3,311,597
13	2028		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2542		2,980,438
14	2029		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2288		2,682,394
15	2030		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2059		2,414,154
16	2031		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1853		2,172,739
17	2032		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1668		1,955,465
18	2033		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1501		1,759,919
19	2034		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1351		1,583,927
20	2035		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1216		1,425,534
21	2036		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1094		1,282,981
22	2037		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0985		1,154,683
23	2038		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0886		1,039,214
24	2039		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0798		935,293
25	2040		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0718		841,764
26	2041		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0646		757,587
27	2042		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0581		681,829
28	2043		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0523		613,646
29	2044		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0471		552,281
30	2045		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0424		497,053
31	2046		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0382		447,348
32	2047		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0343		402,613
33	2048		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0309		362,352
34	2049		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0278		326,116
35	2050		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0250		293,505
	Total	193,300,000							142,484,909	64,763,796

FIRR	4.2%
B/C	0.45
NPV	-77,721,113

Financial Evaluation b)Rubber/Bentonite sheets Project cost=455 Million USD

	Year	Project Cost	Project Benefit				Benefit-Cost	Discount Rate (10%)	Discounted Cost	Discounted Benefit
			Crop	Livestock	O&M Reduction	(Total)				
0	2015							1.0000		
1	2016	91,000,000				0	-91,000,000	0.9000	81,900,000	0
2	2017	91,000,000				0	-91,000,000	0.8100	73,710,000	0
3	2018	91,000,000				0	-91,000,000	0.7290	66,339,000	0
4	2019	91,000,000				0	-91,000,000	0.6561	59,705,100	0
5	2020	91,000,000	8,362,273	1,613,120	1,750,000	11,725,393	-79,274,607	0.5905	53,734,590	6,923,727
6	2021		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.5314		6,231,355
7	2022		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4783		5,608,219
8	2023		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4305		5,047,397
9	2024		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3874		4,542,657
10	2025		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3487		4,088,392
11	2026		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3138		3,679,553
12	2027		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2824		3,311,597
13	2028		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2542		2,980,438
14	2029		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2288		2,682,394
15	2030		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2059		2,414,154
16	2031		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1853		2,172,739
17	2032		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1668		1,955,465
18	2033		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1501		1,759,919
19	2034		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1351		1,583,927
20	2035		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1216		1,425,534
21	2036		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1094		1,282,981
22	2037		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0985		1,154,683
23	2038		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0886		1,039,214
24	2039		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0798		935,293
25	2040		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0718		841,764
26	2041		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0646		757,587
27	2042		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0581		681,829
28	2043		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0523		613,646
29	2044		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0471		552,281
30	2045		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0424		497,053
31	2046		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0382		447,348
32	2047		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0343		402,613
33	2048		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0309		362,352
34	2049		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0278		326,116
35	2050		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0250		293,505
	Total	455,000,000							335,388,690	66,595,730

FIRR	-1.3%
B/C	0.20
NPV	-268,792,960

Financial Evaluation c)Soil cement Project cost=210 Million USD

	Year	Project Cost	Project Benefit				Benefit-Cost	Discount Rate (10%)	Discounted Cost	Discounted Benefit
			Crop	Livestock	O&M Reduction	(Total)				
0	2015							1.0000		
1	2016	41,920,000				0	-41,920,000	0.9000	37,728,000	0
2	2017	41,920,000				0	-41,920,000	0.8100	33,955,200	0
3	2018	41,920,000				0	-41,920,000	0.7290	30,559,680	0
4	2019	41,920,000				0	-41,920,000	0.6561	27,503,712	0
5	2020	41,920,000	8,362,273	1,613,120	1,750,000	11,725,393	-30,194,607	0.5905	24,753,341	6,923,727
6	2021		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.5314		6,231,355
7	2022		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4783		5,608,219
8	2023		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4305		5,047,397
9	2024		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3874		4,542,657
10	2025		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3487		4,088,392
11	2026		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3138		3,679,553
12	2027		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2824		3,311,597
13	2028		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2542		2,980,438
14	2029		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2288		2,682,394
15	2030		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2059		2,414,154
16	2031		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1853		2,172,739
17	2032		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1668		1,955,465
18	2033		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1501		1,759,919
19	2034		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1351		1,583,927
20	2035		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1216		1,425,534
21	2036		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1094		1,282,981
22	2037		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0985		1,154,683
23	2038		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0886		1,039,214
24	2039		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0798		935,293
25	2040		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0718		841,764
26	2041		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0646		757,587
27	2042		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0581		681,829
28	2043		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0523		613,646
29	2044		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0471		552,281
30	2045		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0424		497,053
31	2046		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0382		447,348
32	2047		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0343		402,613
33	2048		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0309		362,352
34	2049		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0278		326,116
35	2050		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0250		293,505
	Total	209,600,000							154,499,933	66,595,730

FIRR	3.6%
B/C	0.43
NPV	-87,904,203

Financial Evaluation d)Bentonite mixing Project cost=241 Million USD

	Year	Project Cost	Project Benefit				Benefit-Cost	Discount Rate (10%)	Discounted Cost	Discounted Benefit
			Crop	Livestock	O&M Reduction	(Total)				
0	2015							1.0000		
1	2016	48,240,000				0	-48,240,000	0.9000	43,416,000	0
2	2017	48,240,000				0	-48,240,000	0.8100	39,074,400	0
3	2018	48,240,000				0	-48,240,000	0.7290	35,166,960	0
4	2019	48,240,000				0	-48,240,000	0.6561	31,650,264	0
5	2020	48,240,000	8,362,273	1,613,120	1,750,000	11,725,393	-36,514,607	0.5905	28,485,238	6,923,727
6	2021		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.5314		6,231,355
7	2022		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4783		5,608,219
8	2023		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.4305		5,047,397
9	2024		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3874		4,542,657
10	2025		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3487		4,088,392
11	2026		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.3138		3,679,553
12	2027		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2824		3,311,597
13	2028		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2542		2,980,438
14	2029		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2288		2,682,394
15	2030		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.2059		2,414,154
16	2031		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1853		2,172,739
17	2032		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1668		1,955,465
18	2033		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1501		1,759,919
19	2034		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1351		1,583,927
20	2035		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1216		1,425,534
21	2036		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.1094		1,282,981
22	2037		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0985		1,154,683
23	2038		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0886		1,039,214
24	2039		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0798		935,293
25	2040		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0718		841,764
26	2041		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0646		757,587
27	2042		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0581		681,829
28	2043		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0523		613,646
29	2044		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0471		552,281
30	2045		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0424		497,053
31	2046		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0382		447,348
32	2047		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0343		402,613
33	2048		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0309		362,352
34	2049		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0278		326,116
35	2050		8,362,273	1,613,120	1,750,000	11,725,393	11,725,393	0.0250		293,505
	Total	241,200,000							177,792,862	66,595,730

FIRR	2.6%
B/C	0.37
NPV	-111,197,132