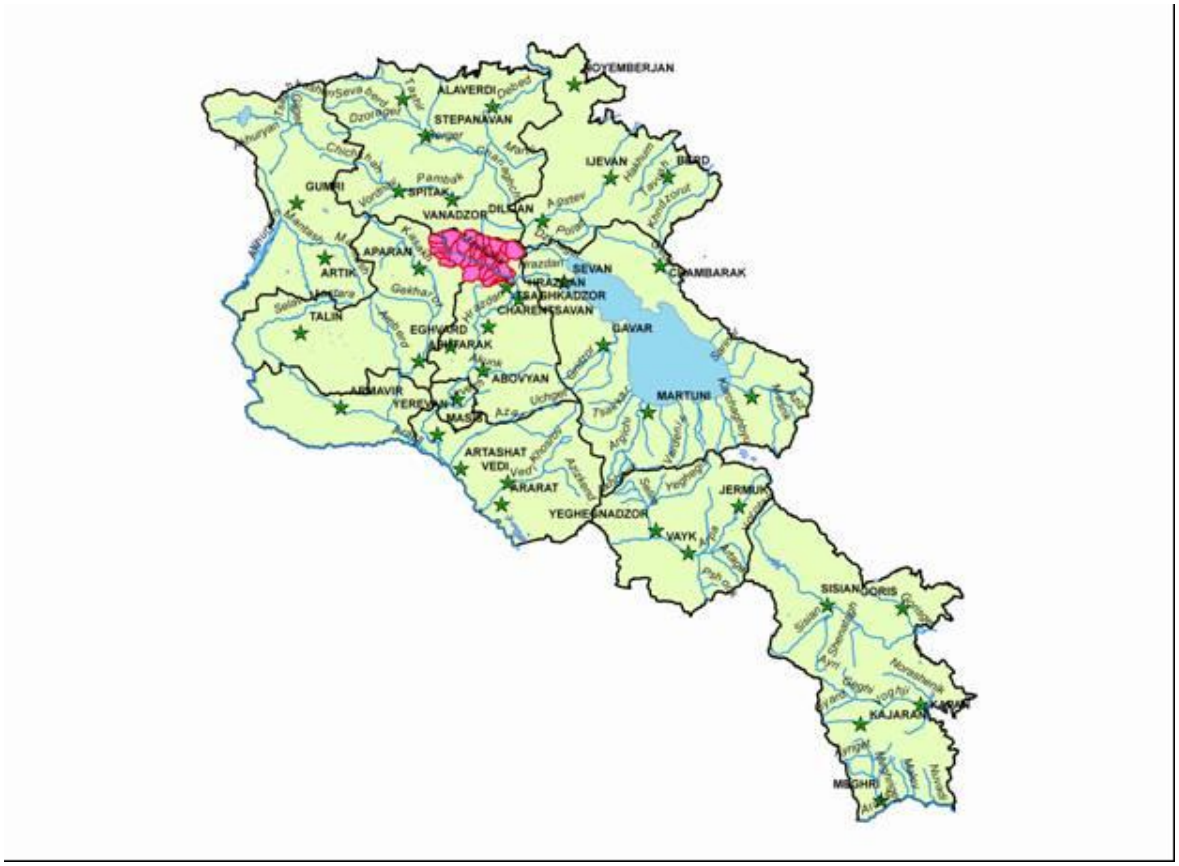
# Desired Conditions for Water Uses and Functions in the Marmarik River Basin, and Identification of Measures to Achieve the Desired Conditions

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# GENERAL DESCRIPTION OF MARMARIK RIVER BASIN

## *Description of the River Basin*

Marmarik River Basin is located in the northern part of Kotayq Marz of the Republic of Armenia (see figure 1). Marmarik River is the largest tributary to Hrazdan River. It has a length of 37 km, and the total area of the watershed is 418 km$^2$, or 1.4% of the total territory of the Republic of Armenia. River flow is formed by the small rivers flowing from Pambak and Tsaghkunyatz mountain ranges. The river flows into Hrazdan River at 116 km above the river mouth. River Marmarik is formed and flows only within the territory of Armenia.

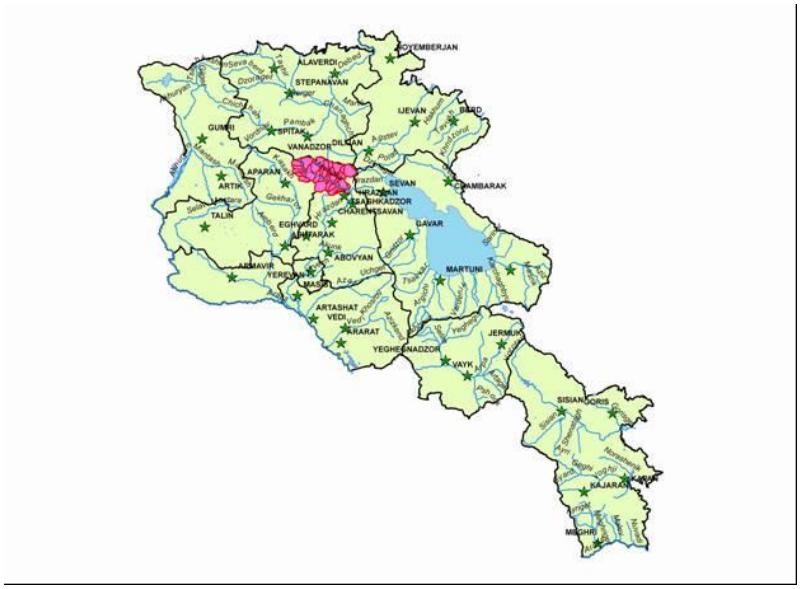


*Figure 1: Location of Marmarik River Basin in Armenia*

Approximately 13% of the territory of the river basin, or 55 km$^2$, is covered by forest, and 35% are irrigated lands. The climate in the river basin is mild, and makes the basin one of the popular resorts centers in Armenia.

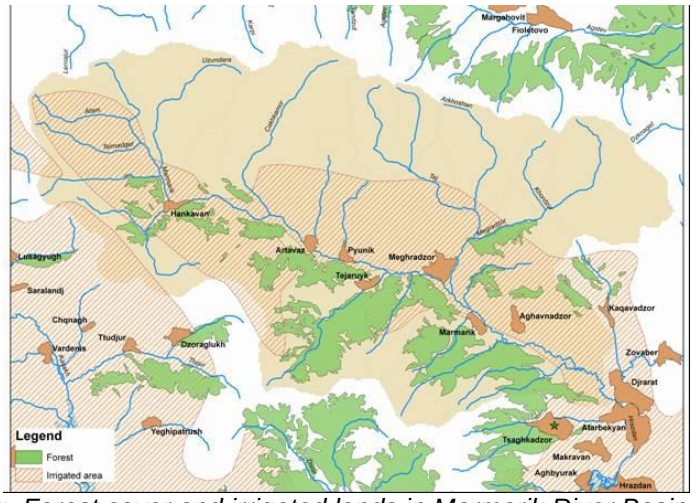


*Figure 2: Forest cover and irrigated lands in Marmarik River Basin*

The main morphological characteristics of Marmarik River are presented in table 1.

*Table 1: Main morphological characteristics of Marmarik River*

| Name of the river | Flows into | Altitude at source, m | Altitude at River mouth, m | Length, km | Average incline | Area of Watershed, $km^2$ |
|---|---|---|---|---|---|---|
| Marmarik | Hrazdan | 2520 | 1699 | 37.0 | 22 | 418 |

Marmarik River Basin includes 12 settlements with more than 7,700 total population. 48.8% of total population is men, and 51.2% women.

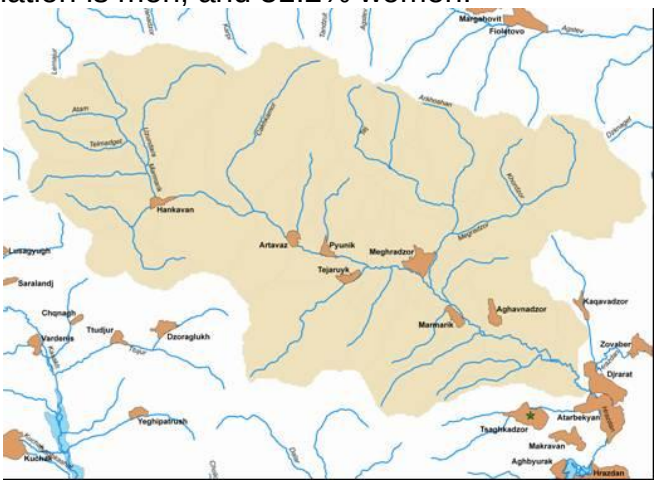


*Figure 3: Settlements of Marmarik River Basin*

Population distribution by settlements is provided in table 2.

*Table 2: Distribution of population in Marmarik River Basin by settlements*

| **Settlement** | **Population number** | **Settlement** | **Population number** |
|---|---|---|---|
| Maqravar | 0 | Meghradzor | 2678 |
| Jrarat | 380 | Tejaruyq | 29 |
| Atarbekyan | 0 | Pyunik | 375 |
| Tsaghkadzor | 1578 | Artavaz | 547 |
| Aghavnadzor | 1261 | Hanqavan | 118 |
| Marmarik | 765 | Kaqavadzir | 0 |
| **Total** | | | **7731** |

## *Hydrological and Morphological Characteristics of Marmarik River*

There are 2 hydrological observation points (Marmarik-Aghavnadzor and Marmarik-Hanqavan) and 2 water quality sampling points in Marmarik River Basin. The table below provides the main hydrological characteristics of Marmarik River in the hydrological observation points Marmarik-Aghavnadzor and Marmarik-Hanqavan.

*Table 3: Hydrological characteristics of the observation points*

| Observation point | W, Flow Volume, $km^2$ | M Flow Module, l/sec. $km^2$ | H, Flow Layer, mm | F, Area of the Watershed, $km^2$ |
|---|---|---|---|---|
| Marmarik-Hanqavan | 0.048 | 16.1 | 509 | 93.5 |
| Marmarik-Aghavnadzor | 0.19 | 15.7 | 494 | 324.5 |

Table 4 provides main morphological characteristics observed in Marmarik-Aghavnadzor hydrological observation point.

*Table 4: Morphological characteristics of Marmarik River*

| | | Flow | | | | | |
|---|---|---|---|---|---|---|---|
| River-observation point | Average altitude, m | Module, l/sec. $km^2$ | Average annual discharge, $m^3$/sec. | Flow coefficient | Seasonal distribution, % | | |
| | | | | | III-VI | VII-XI | XI-II |
| Marmarik-Aghavnadzor | 2350 | 14,5 | 5,43 | 0,57 | 75 | 19 | 6 |

As seen from the table 4, the distribution of flow of Marmarik River is closely related to seasonal variations. Maximum flow is observed in spring months. Afterwards, the flow is mainly formed through feeding from groundwater sources, and to some extent from precipitations.

The multi-year average flow of Marmarik River is highly fluctuating. This is an important thing to know for the guaranteed use of the flow (see table 5).

*Table 5: River flow in calculated sections in average and calculated years*

| River, Calculated Section | Change in flow coefficient | River flow, $m^3$/sec. | | | | |
|---|---|---|---|---|---|---|
| | | 5% | 25% | 50% | 75% | 95% |
| Marmarik-Aghavnadzor | 0.25 | 7,96 | 6,24 | 4,90 | 4,40 | 3,16 |

Multi-year variability of the flow value is expressed with the coefficient $C_V$, which is defined as the ratio of differences in average square value multi-year annual flow and average annual flow. Table 4 presents the changes in flow coefficient for Marmarik River. The change in flow coefficient in the upstream part of Marmarik River is quite high ($C_V$=0.25-0.35 - for all rivers). The volume of flow of the river is highly contingent upon seasonal variations.

As seen from Table 6, Marmarik River has mixed water sources, where, however, melting prevails. Breakdown by months shows that there are also some differences between the warm and cold seasons. During the warm seasons, i.e. between April and October, 60-90% of the total annual flow is observed in the river. Particularly, the upstream segment of the river mainly relates to surface flow. Mudflows in spring are one of the main phases for Marmarik River flow. Usually, the maximum discharge is observed during the spring mudflows.

*Table 6: Sources of the River (%)*

| River-Observation Point | Melting | Precipitation | Underground |
|---|---|---|---|
| Marmarik-Aghavnadzor | 55 | 18 | 27 |

However, for Marmarik River the feeding from groundwater sources has also significant importance. During the summer dry-season periods feeding from groundwater sources prevails. In winter-time the river feeds exceptionally from groundwater sources.

When observed as water use resource, for Marmarik River the flow discharge is very important to observe by average monthly values. Breakdown of annual flow of Marmarik River in years with 50% probability of occurrence of flow is one of such characteristics (Table 7).

*Table 7: Breakdown of annual flow of Marmarik River in years with 50% of flow ($m^3$/sec.)*

| River name | Months | | | | | | | | | | | | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | XI | X | XI | XII | |
| Marmarik-Aghavnadzor | 1.38 | 1.38 | 1.4 | 10.6 | 19.65 | 10.5 | 7.27 | 2.23 | 1.28 | 1.08 | 0.96 | 1.13 | 4.9 |

The above-mentioned characteristics relate to the natural flow of the river. Annual distribution of the river water shows that starting from the month of July the water discharge compared to average annual discharge significantly decreases during intensive water use (mainly irrigation) period.

## *Hydrological Reserve*

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

- Construction of artificial lakes, obstacles, distribution systems, irrigation and drainage systems on the river,
- Change of flow direction of the river,
- Extraction of surface and underground water resources in volumes that have impact on the hydrological regime of the River,
- Discharge of mineral waters into the river, as well as water taken outside of the river basin,
- Draining of forests and wetlands,
- Change of nature of the areas (construction of large open-mines and others),
- Other activities, which might have significant impact on the hydrological regime of the water object.

# IDENTIFICATION OF DESIRED CONDITIONS FOR WATER USES AND FUNCTIONS IN THE MARMARIK RIVER BASIN

## *Identification of Desired Conditions for Water Uses and Functions*

### Current Water Use in Marmarik River Basin

According to 2007 data, approximately 12.6 million $m^3$ of water is being used annually for various purposes from Marmarik River (excluding the annual use of 4.4 mln. $m^3$ of water for hydro-energy purposes). Meghradzor Gold Mine in Marmarik River Basin uses approximately 0.3 million $m^3$ of water from the tributaries to Marmarik River. (The volume of the annual wastewater from the gold mine is 0.13 mln. $m^3$, which is considered as normative wastewater not requiring treatment).

The water use data does not include irrigation water. Irrigated lands compose approximately 35% (146,3 $km^2$) of the total territory of the River Basin. Taking into consideration the guidelines on "Temporary Norms and Periods of Agricultural Irrigation for the Regions of the Armenian SSR", it can be calculated that for the irrigated lands belonging to the rural communities of Meghradzor, Marmarik and Aghavnadzor, annually 3340 $m^3$ of water is required for irrigating 1 ha of agricultural land. Thus the average water demand for irrigation period for those territories is approximately 49 mln. $m^3$/year.

As seen from the table 7, the average annual water discharge in that Marmarik-Aghavnadzor hydrological observation point is roughly 4.9 $m^3$/sec. On its turn, the registered water use is approximately 0.4 $m^3$/sec. If we add to this number the average required quantity for irrigation, we will receive 1.95 $m^3$/sec.

The approximate environmental flow at Marmarik-Aghavnadzor observation point will compose 0,2 $m^3$/sec [1] . (The methodology mentioned in Appendix 2 of the Government of Armenian Resolution No. 592N of 22 March 2003 on “Defining the Volumes of Environmental Flows and Maximum Allowable Limits for Extracting Water in Each Segment of the Water Object”).

If we deduct 0.2 from 4.9 $m^3$/sec, we will obtain the approximate value of the free flow (4,7 $m^3$/sec.). Subtracting the actual water use from this number (1.96 $m^3$/sec.), we will receive the free, usable flow at Marmarik-Aghavnadzor hydrological observation point (2,75 $m^3$/sec.). Thus, currently only 41.7% of the water supply potential of the segment Marmarik-Aghavnadzor of Marmarik River is being used. If we include in the above-mentioned calculations also the hydro-energy, then the water use will compose 2.1 $m^3$/sec. The free, usable flow at Marmarik-Aghavnadzor hydrological observation point is (2,6 $m^3$/sec.). Thus, only 47% of the actual water supply potential

[1]) This number is approximate, since in order to define 95% provision of water more precisely, it is necessary to conduct more detailed studies on minimum flows.

is being used in the territories impacted by hydro-energy, whereas in irrigation period there is a water deficit, which on its turn implies socio-economic issues and complaints from the population.

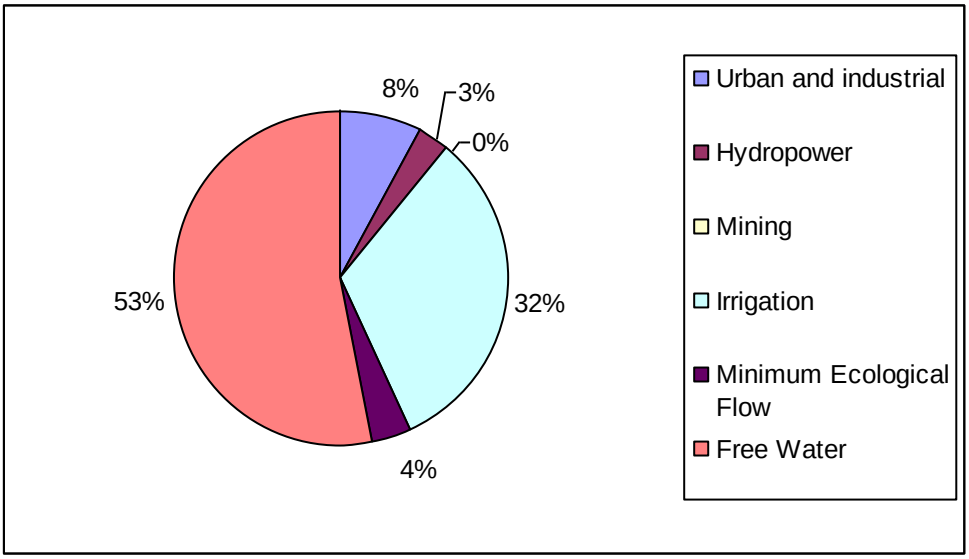


*Figure 4: Distribution of the total annual water use in Marmarik River Basin*

## Water Quality

Water quality monitoring of Marmarik River is being conducted since 1986, by the Environmental Impact Monitoring Center of the Ministry of Nature Protection of Armenia. 24 water-chemical indicators have been determined in samples taken within the period 1986-2004. About 35-45 water-chemical indicators have been analyzed in 2005-2007. The analysis of water quality shows that the water of Marmarik River has average hardness. The concentration of suspended elements is low and is within the allowable limits. Alongside the river no significant changes of the parameters are observed, and their concentration near the river mouth and upstream part of the river is almost the same, within the range of error margin. The oxygen regime of the river for 1986-2007 has been satisfactory and the level of oxygen varied within the range of norm. The level of organic pollutants in the river's water is low and that the river has high self-cleaning potential. The average annual values of all hydro-chemical indicators except from V, Mn and Al, are within the limits of MAC for fisheries. The concentrations of the elements Cr, V, Cu are almost the same near the river mouth and the upstream part and exceed the corresponding MACs for fisheries 2-4 times. This is due to the geo-chemical and hydro-geo-chemical peculiarities of the watershed.

The analysis of the water quality shows that the pollutants and water-chemical indicators can be divided into 5 groups.

The *first group* is composed of biological combinations of Nitrogen (Nitrate, Nitrite, Ammonia, $BOD_5$ and COD). The existence of this group of polluters in the river, upstream parts, and particularly downstream parts, is most likely due to the anthropogenic factors. The unstable and low level of pollution in the upstream segments of the river with Ammonia ions and $BOD_5$ is seasonal, and is most likely related to the use of fertilizers in the river basin. As a result of washing cultivated land

areas, diffused water plenty of Nitrogen combinations flow into the river, which on its turn increases the concentration of the above-mentioned elements in the river and brings to partial, short-term decline in river's water quality. The unstable, low level pollution with Ammonia, Nitrate, Nitrite ions and $BOD_5$ in the upstream segments of the river has also seasonal nature, and is also most likely related to the use of fertilizers in the watershed. As a result of washing cultivated land areas, diffused water plenty of Nitrogen combinations flows into the water, which on its turn increases the concentration of the above-mentioned elements in the river and brings to partial, short-term decline in river's water quality. One cannot also exclude the inflow of wastewater from livestock and households, since there are no wastewater treatment facilities in any of the settlements of the watershed. Such wastewater may flow to river directly or in diffused way and impose additional pressures on the quality of the river. There are several factors for unstable nature and low level of pollution:

- Firstly, the use of fertilizers in the watershed is at decent level.
- Secondly, urbanization in the watershed is at low level, and the volume of household wastewater from settlements, though untreated, is limited.
- Thirdly, cattle-breeding is not very popular in the watershed, and the direct or diffuse polluted inflow to river from livestock is limited.

In general, the pollution from the first group of indicators (biological forms of Nitrogen, $BOD_5$, COD) and violations of oxygen regime is mainly due to anthropogenic factors. However, pressure from the above-mentioned pollutants to the water of the river is not that high. Due to river's high potential of self-cleaning and insignificant pressures with the above-mentioned pollutants there is currently some sort of equilibrium between the processes of pollution and self-cleaning, thanks to which the water in the river high rather high quality.

The *second group* of the polluters compose the heavy metals Cr, Cu, Mn, V. Their concentrations are stable, and exceed the MACs for fisheries. The concentrations of Cr, Cu, Mn, V in the river mouth and upstream segments of the river do not vary too much, which implies that such concentration is background for Marmarik River and is due to the geo-chemical and hydro-chemical peculiarities of the watershed.

The *third group* of polluters compose the heavy metals Zn, Fe, Cr and Al. The concentrations of Zn and Al taken from the upstream segments of the river are within the limits of MAC for fisheries. The concentrations of Zn and Al taken from the river mouth sometimes exceed MAC for fisheries. Some correlation is noticed between the increase of their concentrations and mudflows. Pollution with Fe is unstable, at low level and has strictly seasonal nature in the upstream and downstream segments of the river. Like in the case with Zn and Al, pollution with Fe is characteristic to mudflow periods. Most likely pollution with this group of elements, particularly with Fe, is a result of penetration of surface soil layer to river due to precipitations and melting. In general, the pollution with Fe, Zn and Al is most likely due to the natural pressure, such as the geo-chemical, hydro-chemical and hydro-meteorological peculiarities of the watershed.

The *fourth group* of water-chemical indicators compose the Hardness and ions of Calcium and Magnesium.

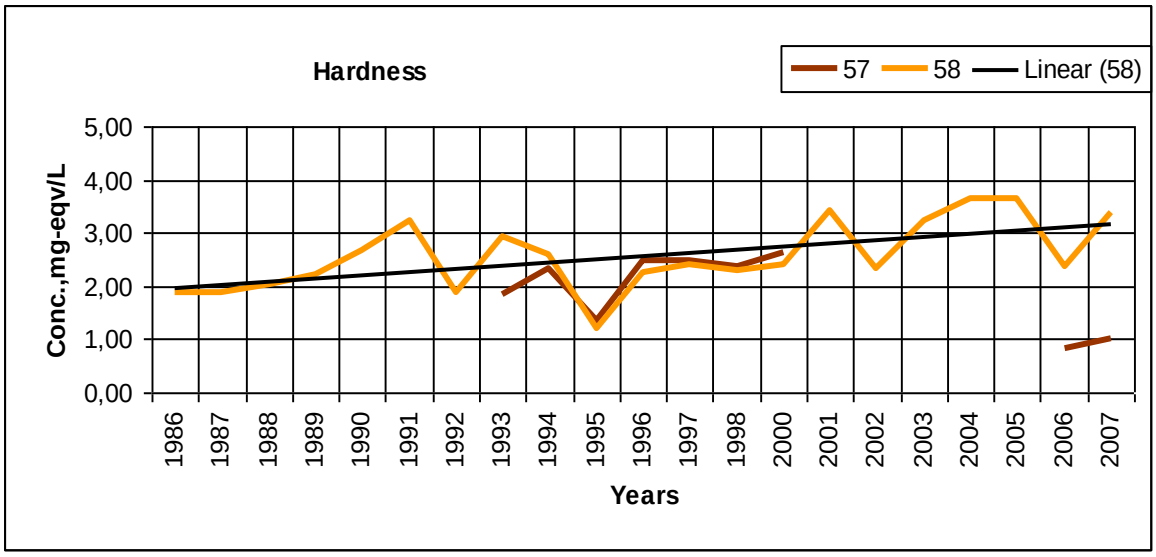


*Figure 5: Changes of average annual values of water hardness for the period 1986-2007*

In the study period a stable growth of hardness values is observed in the river mouth. Until 2000 the hardness of water in the upstream and downstream segments of the river is the same, however, in 2006-2007 significant differences in hardness value are observed. In the upstream sampling point the hardness is much lower. As seen from the figure above, for the period of 1986-2007, the concentration of Calcium in the river mouth increases, and the concentration of Magnesium slightly decreases. This implies that increase is hardness is contingent upon increase of Calcium contents in the water. Before 2000 the concentrations of Calcium and Magnesium in the upstream and downstream segments of the river were the same, however in 2006-2007 in the upstream segment of the river a decrease of concentration for both Calcium and Magnesium is observed. This information explains the differences in the river mouth and upstream segment of the river. However, it does not explain the cause and nature of such occurrence. As a matter of fact, a change in ratio Calcium/Magnesium (g.-equivalent/g. equivalent) occurs in the river mouth. This ratio has grown from 1:1 in 1986 to 2:1 nowadays. Such change also implies that during the last decade some changes in hydro-chemical composition of the watershed occurred. This is probably due to reduction of forest cover in the river basin during the last decade. The reduction of forest cover caused intensification of erosion process in the watershed, as a result of which the inflow and concentration of Calcium in river's water increased.

And, finally, the *fifth group* of water-chemical indicators compose the indicators, for which exceeding of MACs was never observed (mineralization, main anions and others).

Based on the results of monitoring for the period of 2006-2007, water quality of Marmarik River has been calculated according to Oregon Index, Canadian Index, Water Quality Combinatorial Index, Complexity Coefficient and Irrigation Coefficient. The calculations have been done with corresponding methodologies. The calculated indices and coefficients are summarized in Table 8. Assessment of chemical quality of Marmarik River's water has been conducted according to water use purpose, taking into consideration corresponding Maximum Allowable Concentrations (MAC).

*Table 8: Assessment of Marmarik River water quality according to hydro-chemical monitoring results in two water quality sampling points based on Oregon Index, Canadian Index, Water Quality Combinatorial Index, Complexity Coefficient and Irrigation Coefficient, and according to water use type or condition importance of the water resource*

| | | Water use type or conditional importance of the water resource | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Fisheries** | | | | **Household** | | | **Drinking** | | | **Irrigation** |
| Sampling Point No | Year | Oregon | Canadian | WQCI | Complexity coefficient | Canadian | WQCI | Complexity Coefficient | Canadian | WQCI | Complexity Coefficient | Irrigation Coefficient |
| 57 | 2006 | 73.4 | 95.9 | 0.25 | 2.22 | 100 | 0 | 0 | 100 | 0 | 0 | |
| Quality order/ Assessment | | 4 Poor | 1 Excellent | 1 Excellent | 1 Good | 1 Excellent | 1 Excellent | 1 Good | 1 Excellent | 1 Excellent | 1 Good | 1 Excellent |
| 58 | 2006 | 73.9 | 55 | 2.11 | 7.19 | 80.5 | 0.83 | 2.83 | 93.6 | 0.52 | 0.98 | |
| Quality order/ Assessment | | 4 Poor | 3 Marg | 3 Fair | 1 Good | 2 Good | 1 Excellent | 1 Good | 2 Good | 1 Excellent | 1 Good | 1 Excellent |
| 57 | 2007 | 73.9 | 80.7 | 1.09 | 5.16 | 87.1 | 0.4 | 1.89 | 93.7 | 0.4 | 1.39 | |
| Quality order/ Assessment | | 4 Poor | 2 Good | 2 Good | 1 Good | 2 Good | 1 Excellent | 1 Good | 1 Good | Excellent | 1 Good | 1 Excellent |
| 58 | 2007 | 64.4 | 84.3 | 0.67 | 3.02 | 88.4 | 0.63 | 3.02 | 96.2 | 0.3 | 0.79 | |
| Quality order/ Assessment | | 4 Poor | 2 Good | 2 Good | 1 Good | 2 Good | 1 Excellent | 1 Good | 1 Excellent | Excellent | 1 Good | 1 Excellent |

This shows that for the purposes of fisheries, household, drinking and irrigation, water quality of Marmarik River is of excellent of good condition. From this it can be applied that the water is Marmarik River can be considered as high quality for the purposes of fisheries, household, drinking and irrigation.

## Generalization of Current Problems

The analysis of baseline conditions and pressures in the Marmarik River basin shows that there are several preferred issues in this regards. Those issues are presented in table 9:

*Table 9: Summary of the main issues and relevant causes in Marmarik River Basin*

| Problem/Issue | Cause |
|---|---|
| Non-utilized free flow of Marmarik River and its tributaries | Improper management/regulation of water flow |
| Water deficit during irrigation season | Inadequate level of development of irrigation systems |
| Floods and mudflows in the River basin | Insufficient level of implementation of flood-control measures |
| Non-utilization of hydroenergy potential of Marmarik River | Inadequate level of development of hydroenergy sector in the basin |
| Potential increase trend of biological substances in waters, which is highly undesirable | Absence of sewage collector networks in rural communities |
| Potential increase of Nitrogen concentrations in water, which is highly undesirable | Diffused pollution from agricultural sources |
| Increase of Calcium concentration in water and harness of water | Increase of erosion process and erosion due to reduction of forest cover in the river basin |
| Violation of regimes of hydrological reserve | Inadequate legal and institutional capacity for protection of hydrological reserve |

Based on the analysis of the main identified issues and risks in Marmarik River Basin, a table has been prepared, which presents a linkage among the issues, risks and water use functions (see Table 10).

*Table 10: The mutual linkage between the water abstraction purposes and functions and issues/problems characteristic to Marmarik River Basin*

| Problems* | Health Care and socio-economic situation of population | Natural functioning of ecosystem | Amateur fishing and small-scale fisheries | Tourism and recreation | Drinking-household water | Irrigation | Industry | Hydroenergy | Tendency for the coming years |
|---|---|---|---|---|---|---|---|---|---|
| Seasonal water scarcity | **P** | | **P** | **P** | | **P** | **P** | **P** | ↑ |
| Flooding and mudflows | | | **P** | **P** | | **P** | | | **risk** |
| Erosion | **P** | **P** | | **P** | **P** | | | **P** | ↑ |
| Origination and collection of sediments | **P** | **P** | | **P** | **P** | | | **P** | **risk** |
| Salinization | | **P** | | | **P** | **P** | **P** | | **risk** |
| Reduction of Forest cover | **P** | **P** | | **P** | **P** | | | | ↑ |
| Pollution with organic substances | **P** | **P** | **P** | **P** | **P** | | | | ↑ |
| Eutrophication | **P** | **P** | **P** | **P** | **P** | **P** | **P** | | **risk** |
| Pollution with poisonous substances (metals, poisonous chemicals) | **P** | **P** | **P** | **P** | **P** | **P** | | | **risk** |
| **P** | **Existence of Problems or Risks** | | | | | | | | |
| **P** | **Priority Problems** | | | | | | | | |
| ↑ | These problems might become acute, particularly parallel to development of economy, if no preventive measures are taken on time. | | | | | | | | |

## Strategy for Formulation of Water Supply in Marmarik River Basin

The main distribution of the free flow relates to accumulation of the water resources. The accumulated water resources can be further distributed equally in order to meet the water demand. This can be solved through constructing new reservoirs.

Previously Marmarik reservoir was being built on Marmarik River, which should have accumulated 24 mln. $m^3$ of water from Marmarik River free flow. This would satisfy part of the water deficit occurring particularly in the field of agriculture. However, because of low quality construction works, the reservoir has not been exploited since completion of construction. Currently works are undertaken for renovation of the reservoir within the frameworks of the Word Bank "Irrigation Dam Safety" Project.

In the long-term development program of reservoir construction it is anticipated to build the Meghradzor reservoir in Marmarik River Basin with an overall volume of 9 mln $m^3$.

The tables below present information on strategy for storage of water resources (including the National Water Reserve and Strategic Water Reserve) in Marmarik River Basin.

*Table 11: Planned and uncompleted reservoirs in Kotayq marz and Marmarik River Basin*

| No. | Name of the Reservoir | Volume, mln. $m^3$ | Status |
|---|---|---|---|
| 1. | Meghradzor | 9.0 | *Planned* |
| 2. | Marmarik | 24.0 | *Uncompleted/planned* |

Reservoir construction project implementation will establish additional capacities to storage approximately annually 33 mln. $m^3$ of water only for Marmarik River, which on its turn will make it possible to extend the possibilities for regulating water resources. This will also solve several strategic issues, including the following:

- Extend irrigated land areas,
- Replace the majority of mechanical/pumped irrigation systems to gravity ones,
- Establish new potential for increasing energy capacity of the country,
- Protect settlements, agricultural lands and communication roads located nearby the river bank from frequent mudflows and flooding,
- Provide for water supply in dry areas of the Republic,
- Define and develop water protection and recreation zones.

## *Drawing up Conclusions and Recommendations for the Identification Process*

Several priorities of development in the Republic of Armenia are defined by development and strategic programs of the Republic, the logic and tendency of socio-economic development of river basins, as well as strategies for protection, efficient management and use of water resources.

The main direction of the desired conditions of water uses and water resources are defined according to Republic of Armenia laws “On Fundamental Provisions of the National Water Policy” and “On National Water Program”, as well as according to several regulatory documents and government decisions.

The republican priorities of development are briefly presented below:

- Development of agriculture and irrigation systems;
- Management and regulation of the river flow, including construction of flood-control structures and development of reservoirs;
- Development of alternative energy sources, including development of hydroenergy through promotion of constructing small hydro-power plants;
- Protection and rational use of water resources;
- Environmental protection;
- Rational use of natural resources;
- Development of tourism and recreation;
- Development of industry, including small and medium enterprises.

While defining priorities for water uses and functions in Marmarik River Basins we have taken into consideration the development priorities both from the national perspective and the development priorities in Marmarik River Basin. The desired conditions are identified taking into consideration the quantity and quality of water supply, while keeping in mind the need to exclude the anthropogenic impact on ecosystems to the extent possible.

Particularly, we have taken into consideration the current water use in Marmarik River Basin, water quality assessed by different complex methods, the analysis of current issues and problems, as well as strategy of formation water supply in the river basin. In addition to this, it was taken into consideration the dynamics and anticipated changes in development of water resources, including the dynamics of water quality changes.

Thus, combining the republican priorities of development, as well as peculiarities of the river basin, desired priority water uses for Marmarik River Basin have been defined according to the following order: satisfaction of drinking-household water requirements, maintenance of hydrological reserve, provision of water for recreation, provision of water for hydroenergy purposes, satisfaction of irrigation demand and provision of water of industrial purposes. Of course, while defining the priorities, a special attention should be paid to maintenance of minimum ecological flow, which is included in calculations of both water supply and water demand. And finally, all the above-mentioned priorities shall be correlated with maintenance of appropriate water quality.

It should be noted that the proposed priority water uses in Marmarik River Basin coincide with the priorities mentioned in the legislation of the Republic of Armenia. The only exception is the hydroenergy, which is prioritized higher compared to irrigation. Such approach is proposed taking into consideration the hydroenergy potential of the river basin, as well as the fact that the water returns to river basin after being used for hydroenergy purposes.

In order to achieve the desired priority conditions of water uses defined for Marmarik River Basin the following target directions are suggested:

*Table 12: Priority Water Uses and Target Directions in Marmarik River Basin*

| Water use priority | Target direction |
|---|---|
| Drinking-Household | Development of a system for strict protection of drinking and mineral water resources, as well as their efficient use |
| Hydrological Reserve | Expansion of the territory of the hydrological reserve and strengthening of the protection regime |
| Recreation Zone | Protection and development of water resources for the purposes of recreation |
| Hydroenergy | Development of hydroenergy through construction of small hydro-power plants |
| Irrigation | Management and regulation of the river flow, including construction of reservoirs |
| | Development of Irrigation Systems |
| Industry | Clarification of industrial water use conditions and development of appropriate enforcement mechanisms |

As of target directions for water quality protection, they are presented in the table below:

*Table 13: Target directions for water quality in Marmarik River Basin*

| Priority | Target Direction |
|---|---|
| Water Quality Protection | Introduction and development of a system for discharge and treatment of point source wastewaters in the river basin |
| | Development of a system for prevention of origination of diffused wastewater and pollution of water resources |
| | Development of a system for reduction and prevention of erosion in the river basin |

In order to achieve the above-mentioned priorities measures have been developed for the following purposes:

- strengthening the legal/regulatory framework to achieve the desired conditions in Marmarik River Basin;
- strengthening the institutional framework to achieve the desired conditions in Marmarik River Basin;
- implementation of technical measures to achieve the desired conditions in Marmarik River Basin.

All the proposed measures are presented in the next section of this report. All the proposed priority measures are important components for introduction of IWRM principles, which are also mainly applicable for the other river basins of the Republic of Armenia.

# IDENTIFICATION OF MEASURES TO ACHIEVE DESIRED CONDITIONS IN MARMARIK RIVER BASIN

## *Introduction*

Before defining legal, institutional and technical measures, let us recall the proposed target directions for achieving the desired water uses and functions in Marmarik River Basin:

- Target direction 1 - Development of a system for strict protection of drinking and mineral water resources, as well as their efficient use.
- Target direction 2 - Expansion of the territory of the hydrological reserve and strengthening of the protection regime.
- Target direction 3 - Protection and development of water resources for the purposes of recreation.
- Target direction 4 - Development of hydroenergy through construction of small hydro-power plants.
- Target direction 5 - Management and regulation of the river flow, including construction of reservoirs.
- Target direction 6 - Development of irrigation systems.
- Target direction 7 - Clarification of industrial water use conditions and development of appropriate enforcement mechanisms.
- Target direction 8 - Introduction and development of a system for discharge and treatment of point source wastewaters in the river basin
- Target direction 9 - Development of a system for prevention of origination of diffused wastewater and pollution of water resources
- Target direction 10 - Development of a system for reduction and prevention of erosion in the river basin.

For the above-mentioned 10 target directions corresponding measures have been developed, which include legal and institutional measures to achieve the target directions, as well as implementation of relevant technical measures.

## *Identification of Measures to Strengthen the Legal/Regulatory Framework to Achieve the Desired Conditions*

The following measures are proposed to strengthen the legal and regulatory framework for achieving the desired conditions:

- Target direction 1 - Development of a system for strict protection of drinking and mineral water resources, as well as their efficient use
    1. Adoption and implementation of minimum water quality requirements prepared within the National Policy Dialogue in Armenia for the communities with self-supply drinking water systems;
- Target direction 2 - Expansion of the territory of the hydrological reserve and strengthening of the protection regime

2. Make the legal status of the “Marmarik Hydrological Reserve” corresponding to the provisions of the Republic of Armenia Law “On Nature Protected Armenia”, including definition of its category of protection and approaches;

- Target direction 3 - Protection and development of water resources for the purposes of recreation
    3. Define the water protection zones and sanitary requirements applied on recreational zones;
- Target direction 4 - Development of hydroenergy through construction of small hydro-power plants
    4. Development of incentive measures to promote construction of small hydro-power plants;
- Target direction 5 - Management and regulation of the river flow, including construction of reservoirs
    5. Initiate legal changes in order to promote regulation of water flow, particularly construction of reservoirs (e.g. application of differentiated, seasonal water resource use fee, provision of tax exemptions);
- Target direction 6 - Development of irrigation systems
    6. Initiate legal changes in order to promote introduction of water saving technologies (e.g. drip irrigation);
- Target direction 7 - Clarification of industrial water use conditions and development of appropriate enforcement mechanisms
    7. Development of industrial water abstraction quantity and quality standards;
    8. Development of self-monitoring mechanisms for industrial water use;
- Target direction 8 - Introduction and development of a system for discharge and treatment of point source wastewaters in the river basin
    9. Development and application of method on self-cleaning capacity of Marmarik River and its tributaries;
    10. Revision of water use permit conditions issued in Marmarik River Basin to improvement the situation with point-source wastewaters;
- Target direction 9 - Development of a system for prevention of origination of diffused wastewater and pollution of water resources
    11. Development of regulation to promote the use of alternative to nitrogen fertilizers in Marmarik River basin;
    12. Development of regulation on exemplary farm economy;
    13. Development of regulation to promote the use of alternative to poisonous chemicals fertilizers in the river basin;
- Target direction 10 - Development of a system for reduction and prevention of erosion in the river basin
    14. Development of legal mechanisms for promoting reforestation works.

## *Identification of Measures to Strengthen the Institutional Framework to Achieve the Desired Conditions*

The following measures are proposed to strengthen the institutional framework for achieving the desired conditions:

- Target direction 1 - Development of a system for strict protection of drinking and mineral water resources, as well as their efficient use
    15. Further to recommendations of JICA Study for Improvement of Rural Water Supply and Discharge in the Republic of Armenia, develop options for institutional set-up of drinking water supply in Marmarik River Basin (e.g. set up of autonomous organizations in charge of operation and maintenance of the system, transfer of operation and maintenance functions to the Armenian Water Supply Company, management through public-private partnership. etc.);
- Target direction 2 - Expansion of the territory of the hydrological reserve and strengthening of the protection regime
    16. Establish a unit within the Ministry of Nature Protection in charge of hydrological reserves;
- Target direction 3 - Protection and development of water resources for the purposes of recreation
    17. Strengthening of enforcement mechanisms with the Basin Management Organizations (BMO) under Water Resources Management Agency (WRMA) and State Hygiene and Anti-Epidemiological Inspectorate (SHAEI) under the Ministry of Health;
- Target direction 4 - Development of hydroenergy through construction of small hydro-power plants
    18. Provide training and technical strengthening of BMOs for efficient monitoring of hydro-energy water use permit conditions;
- Target direction 5 - Management and regulation of the river flow, including construction of reservoirs
    19. Strengthening the capacities of BMOs, WUAs and local self-governance authorities on management and regulation of the water flow;
- Target direction 6 - Development of irrigation systems
    20. Capacity building and strengthening of Water Users' Associations (WUA) for development of irrigation systems and improvement of irrigation practices;
- Target direction 7 - Clarification of industrial water use conditions and development of appropriate enforcement mechanisms
    21. Strengthen the capacities of BMOs and State Environmental Inspectorates (SEI) on enforcing industrial water use permit conditions;
- Target direction 8 - Introduction and development of a system for discharge and treatment of point source wastewaters in the river basin
    22. Strengthen the capacities of BMOs, SEIs and Environmental Impact Monitoring Center (EIMCs) water monitoring wastewater discharge and treatment;
- Target direction 9 - Development of a system for prevention of origination of diffused wastewater and pollution of water resources
    23. Training of the staff of "Hayantar" ("Armenian Forests" ) State Non-Commercial Organization and local self-governance authorities on preventing pollution of water resources from diffused sources through reforestation activities;
- Target direction 10 - Development of a system for reduction and prevention of erosion in the river basin

24. Strengthening the capacities of “Hayantar”, local self-governance authorities and WUAs on preventing erosion in the river basin.

## *Identification of Technical Measures to Achieve the Desired Conditions*

The following technical measures are proposed to achieve the desired conditions:

- Target direction 1 - Development of a system for strict protection of drinking and mineral water resources, as well as their efficient use
    25. Installation of water meters to control drinking water use;
    26. Installation of drinking water treatment stations;
    27. Rehabilitation of drinking water supply systems, including water intake structures, transmission and distribution pipelines, daily regulatory reservoirs, and house connections;
- Target direction 2 - Expansion of the territory of the hydrological reserve and strengthening of the protection regime
    28. Conducting an inventory of natural resources in “Marmarik” hydrological reserve;
- Target direction 3 - Protection and development of water resources for the purposes of recreation
    29. Development of audio-video information materials;
    30. Clarification of the boundaries of water protection and recreation zones;
- Target direction 4 - Development of hydroenergy through construction of small hydro-power plants
    31. Increasing public awareness on the efficiency of small hydro-power plants;
- Target direction 5 - Management and regulation of the river flow, including construction of reservoirs
    32. Rehabilitation of the two reservoirs (Meghradzor and Marmarik) in the basin;
    33. Conduct studies of other options of managing and regulating the water flow in the basin;
- Target direction 6 - Development of irrigation systems
    34. Implementation of pilot project on introduction of drip irrigation in two rural communities (in the area of 1-2 ha in each community) of Marmarik River Basin;
- Target direction 7 - Clarification of industrial water use conditions and development of appropriate enforcement mechanisms
    35. Development of Environmental Management System for the industries in Marmarik River Basin in the line with the requirements for water ecosystems;
- Target direction 8 - Introduction and development of a system for discharge and treatment of point source wastewaters in the river basin
    36. Construction of local wastewater treatment facilities in the river basin for large communities, hotels, resorts, as well as large farms;
    37. Development and implementation of pilot projects on biogas production;
- Target direction 9 - Development of a system for prevention of origination of diffused wastewater and pollution of water resources

38. Replacement of land-processing directions and technologies with the ones with low risk, to the extent possible;
39. Development of forest protection zones in the agricultural land areas of the river basin;
40. Development of forest protection zone in the banks of the river;

- Target direction 10 - Development of a system for reduction and prevention of erosion in the river basin
  41. Implementation of reforestation activities in the river basin, perspective and mass expansion of forest cover in the basin.

## *Summary*

Thus, more than 40 legal, institutional and technical measures are proposed for implementation, which will help to achieve the desired condition for water uses and functions in Marmarik River Basin. The diagram below presents the logical sequence of the steps undertaken for achieving the desired water uses and water quality in Marmarik River Basin. First, we defined the desired conditions based on the detailed analysis of current issues and problems, after which 10 target directions were defined. And finally, corresponding legal, institutional and technical measures were proposed to achieve desired conditions.

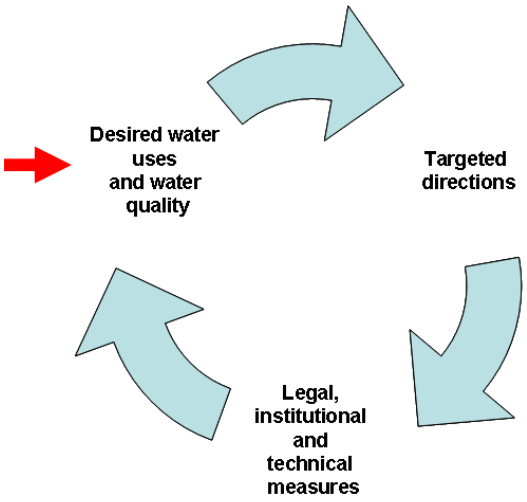


*Figure 6: Diagram of sequence of steps for setting desired conditions in Marmarik River Basin*

And, finally the combined table of all measures is presented below:

*Table 14: Combined table of proposed measures in Marmarik River Basin*

| Desired Conditions | Priority | Target Directions | Legal Measures | Institutional Measures | Technical Measures |
|---|---|---|---|---|---|
| Quantity | Drinking-Household | Development of a system for strict protection of drinking and mineral water resources, as well as their efficient use | Adoption and implementation of minimum water quality requirements prepared within the National Policy Dialogue in Armenia for the communities with self-supply drinking water systems | Further to recommendations of JICA Study for Improvement of Rural Water Supply and Discharge in the Republic of Armenia, develop options for institutional set-up of drinking water supply in Marmarik River Basin (e.g. set up of autonomous organizations in charge of operation and maintenance of the system, transfer of operation and maintenance functions to the Armenian Water Supply Company, management through public-private partnership) | Installation of water meters to control drinking water use |
| | | | | | Installation of drinking water treatment stations |
| | | | | | Rehabilitation of drinking water supply systems, including water intake structures, transmission and distribution pipelines, daily regulatory reservoirs, and house connections |
| | Hydrological Reserve | Expansion of the territory of the hydrological reserve and strengthening of the protection regime | Make the legal status of the “Marmarik Hydrological Reserve” corresponding to the provisions of the Republic of Armenia Law “On Nature Protected Armenia”, including definition of its category of protection and approaches | Establish a unit within the Ministry of Nature Protection in charge of hydrological reserves | Conducting an inventory of natural resources in “Marmarik” hydrological reserve |
| | Recreation Zone | Protection and development of water resources for the purposes of recreation | Define the water protection zones and sanitary requirements applied on recreational zones | Strengthening of enforcement mechanisms with the Basin Management Organizations (BMO) under Water Resources Management Agency (WRMA) and State Hygiene and Anti-Epidemiological Inspectorate (SHAEI) | Development of audio-video information materials |
| | | | | | Clarification of the boundaries of water protection and recreation zones |

| Desired Conditions | Priority | Target Directions | Legal Measures | Institutional Measures | Technical Measures |
|---|---|---|---|---|---|
| | Hydroenergy | Development of hydroenergy through construction of small hydro-power plants | Development of incentive measures to promote construction of small hydro-power plants | Provide training and technical strengthening of BMOs for efficient monitoring of hydro-energy water use permit conditions | Increasing public awareness on the efficiency of small hydro-power plants |
| | Irrigation | Management and regulation of the river flow, including construction of reservoirs | Initiate legal changes in order to promote regulation of water flow, particularly construction of reservoirs (e.g. application of differentiated, seasonal water resource use fee, provision of tax exemptions) | Strengthening the capacities of BMOs, WUAs and local self-governance authorities on management and regulation of the water flow | Rehabilitation of the two reservoirs (Meghradzor and Marmarik) in Marmarik River Basin |
| | | | | | Conduct studies of other options of managing and regulating the water flow in the basin |
| | | Development of Irrigation Systems | Initiate legal changes in order to promote introduction of water saving technologies (e.g. drip irrigation) | Capacity building and strengthening of Water Users' Associations (WUA) for development of irrigation systems and improvement of irrigation practices | Implementation of pilot project on introduction of drip irrigation in two rural communities (in the area of 1-2 ha in each community) of Marmarik River Basin |
| | Industry | Clarification of industrial water use conditions and development of appropriate enforcement mechanisms | Development of industrial water abstraction quantity and quality standards | Strengthen the capacities of BMOs and State Environmental Inspectorates (SEI) on enforcing industrial water use permit conditions | Development of Environmental Management System for the industries in Marmarik River Basin in the line with the requirements for water ecosystems |
| | | | Development of self-monitoring mechanisms for industrial water use | | |
| Quality | Water Quality Protection | development of a system for discharge and treatment of point source wastewaters | Development and application of method on self-cleaning capacity of Marmarik River and its tributaries | Strengthen the capacities of BMOs, SEIs and Environmental Impact Monitoring Center (EIMCs) water monitoring wastewater discharge and treatment | Construction of local wastewater treatment facilities in the river basin for large communities, hotels, resorts, as well as large farms |

| Desired Conditions | Priority | Target Directions | Legal Measures | Institutional Measures | Technical Measures |
|---|---|---|---|---|---|
| | | | Revision of water use permit conditions issued in the Basin to improvement the situation with point-source wastewaters | | Development and implementation of pilot projects on biogas production |
| | | Development of a system for prevention of origination of diffused wastewater and pollution of water resources | Development of regulation to promote the use of alternative to nitrogen fertilizers in Marmarik River basin | Training of the staff of “Hayantar” (“Armenian Forests” ) State Non-Commercial Organization and local self-governance authorities on preventing pollution of water resources from diffused sources through reforestation activities | Replacement of land-processing directions and technologies with the ones with low risk, to the extent possible |
| | | | Development of regulation on exemplary farm economy | | Development of forest protection zones in the agricultural land areas of the river basin |
| | | | Development of regulation to promote the use of alternative to poisonous chemicals fertilizers in the river basin | | Development of forest protection zone in the banks of the river |
| | | Development of a system for reduction and prevention of erosion in the river basin | Development of legal mechanisms for promoting reforestation works | Strengthening the capacities of “Hayantar”, local self-governance authorities and WUAs on preventing erosion in the river basin | Implementation of reforestation activities in the river basin, perspective and mass expansion of forest cover in the basin |

# PRELIMINARY COST ESTIMATES OF IDENTIFIED MEASURES

## *Methodology*

For each of the identified legal/regulatory, institutional and technical measures, described in the previous chapter of the report, very preliminary cost estimate has been prepared. Basically, the cost estimate provide for the approximate level of financial input required for the implementation of the corresponding measure. Preliminary cost estimates are prepared using experts' judgment methods, as well as through consultations with major stakeholders in Marmarik River basin.

According to their preliminary budgets, the projects have been grouped into the following categories:

- I category projects require financing between 0-100,000 USD,
- II category projects require financing between 100,000-300,000 USD,
- III category projects require financing between 300,000-500,000 USD,
- IV category projects require financing between 500,000-1,000,000 USD,
- V category projects require financing of over 1 million USD.

The following sections provide a preliminary estimate of legal, institutional and technical measures, as well as combined description of financial requirements according to targets for achieving desired water quantity and quality conditions in Marmarik River basin.

## *Legal and Regulatory Meausres*

The preliminary cost estimate of the proposed legal and regulatory measures is presented in the table below.

*Table 15: Proposed legal and regulatory measures*

| Target Direction | Measure No. | Measure Description | Budget Order | Preliminary Cost |
|---|---|---|---|---|
| ***Measures within estimated rough budget of 0-100,000 USD*** | | | | |
| 1 | 1 | Adoption and implementation of minimum water quality requirements prepared within the National Policy Dialogue in Armenia for the communities with self-supply drinking water systems | **I** | **50,000** |
| 2 | 2 | Make the legal status of the “Marmarik Hydrological Reserve” corresponding to the provisions of the Republic of Armenia Law “On Nature Protected Armenia”, including definition of its category of protection and approaches | **I** | **60,000** |
| 3 | 3 | Define the water protection zones and sanitary requirements applied on recreational zones | **I** | **30,000** |
| 4 | 4 | Development of incentive measures to promote construction of small hydro-power plants | **I** | **50,000** |
| 6 | 6 | Initiate legal changes in order to promote introduction of water saving technologies (e.g. drip irrigation); | **I** | **50,000** |
| 7 | 8 | Development of self-monitoring mechanisms for industrial water use | **I** | **30,000** |
| 8 | 10 | Revision of water use permit conditions issued in Marmarik River Basin to improvement the situation with point-source wastewaters | **I** | **15,000** |

| Target Direction | Measure No. | Measure Description | Budget Order | Preliminary Cost |
|---|---|---|---|---|
| 9 | 11 | Development of regulation to promote the use of alternative to nitrogen fertilizers in Marmarik River basin | **I** | **150,000** |
| 9 | 12 | Development of regulation on exemplary farm economy | **I** | **15,000** |
| 9 | 13 | Development of regulation to promote the use of alternative to poisonous chemicals fertilizers in the river basin | **I** | **25,000** |
| 10 | 14 | Development of legal mechanisms for promoting reforestation works | **I** | **25,000** |
| ***Measures within estimated rough budget of 100,000-300,000 USD*** | | | | |
| 5 | 5 | Initiate legal changes in order to promote regulation of water flow, particularly construction of reservoirs (e.g. application of differentiated, seasonal water resource use fee, provision of tax exemptions) | **II** | **200,000** |
| 7 | 7 | Development of industrial water abstraction quantity and quality standards | **II** | **200,000** |
| 8 | 9 | Development and application of method on self-cleaning capacity of Marmarik River and its tributaries | **II** | **250,000** |
| | | **Total** | | **1,150,000** |

## *Institutional Measures*

The preliminary cost estimate of the proposed institutional measures is presented in the table below.

*Table 16: Proposed institutional measures*

| Target Direction | Measure No. | Measure Description | Budget Order | Preliminary Cost |
|---|---|---|---|---|
| ***Measures within estimated rough budget of 0-100,000 USD*** | | | | |
| 1 | 15 | Further to recommendations of JICA Study for Improvement of Rural Water Supply and Discharge in the Republic of Armenia, develop options for institutional set-up of drinking water supply in Marmarik River Basin (e.g. set up of autonomous organizations in charge of operation and maintenance of the system, transfer of operation and maintenance functions to the Armenian Water Supply Company, management through public-private partnership. etc.); | **I** | **75,000** |
| 3 | 17 | Strengthening of enforcement mechanisms with the Basin Management Organizations (BMO) under Water Resources Management Agency (WRMA) and State Hygiene and Anti-Epidemiological Inspectorate (SHAEI) under the Ministry of Health | **I** | **25,000** |
| 4 | 18 | Provide training and technical strengthening of BMOs for efficient monitoring of hydro-energy water use permit conditions | **I** | **10,000** |
| 5 | 19 | Strengthening the capacities of BMOs, WUAs and local self-governance authorities on management and regulation of the water flow | **I** | **15,000** |
| 6 | 20 | Capacity building and strengthening of Water Users' Associations (WUA) for development of irrigation systems and improvement of irrigation practices | **I** | **20,000** |
| 7 | 21 | Strengthen the capacities of BMOs and State Environmental Inspectorates (SEI) on enforcing industrial water use permit conditions | **I** | **15,000** |
| 8 | 22 | Strengthen the capacities of BMOs, SEIs and Environmental Impact Monitoring Center (EIMCs) water monitoring wastewater discharge and treatment | **I** | **15,000** |

| | | | | |
|---|---|---|---|---|
| 9 | 23 | Training of the staff of “Hayantar” (“Armenian Forests” ) State Non-Commercial Organization and local self-governance authorities on preventing pollution of water resources from diffused sources through reforestation activities | **I** | **15,000** |
| 10 | 24 | Strengthening the capacities of “Hayantar”, local self-governance authorities and WUAs on preventing erosion in the river basin | **I** | **15,000** |
| ***Measures within estimated rough budget of 100,000-300,000 USD*** | | | | |
| 2 | 16 | Establish a unit within the Ministry of Nature Protection in charge of hydrological reserves | **II** | **200,000** |
| | | **Total** | | **405,000** |

## *Technical Measures*

The preliminary cost estimate of the proposed technical measures is presented in the table below.

*Table 17: Proposed technical measures*

| Target Direction | Measure No. | Measure Description | Budget Order | Preliminary Cost |
|---|---|---|---|---|
| ***Measures within estimated rough budget of 0-100,000 USD*** | | | | |
| 3 | 29 | Development of audio-video information materials | **I** | **20,000** |
| 3 | 30 | Clarification of the boundaries of water protection and recreation zones | **I** | **35,000** |
| 4 | 31 | Increasing public awareness on the efficiency of small hydro-power plants | **I** | **10,000** |
| 5 | 33 | Conduct studies of other options of managing and regulating the water flow in the basin | **I** | **10,000** |
| 6 | 34 | Implementation of pilot project on introduction of drip irrigation in two rural communities (in the area of 1-2 ha in each community) of Marmarik River Basin | **I** | **25,000** |
| ***Measures within estimated rough budget of 100,000-300,000 USD*** | | | | |
| 1 | 25 | Installation of water meters to control drinking water use | **II** | **150,000** |
| 2 | 28 | Conducting an inventory of natural resources in “Marmarik” hydrological reserve | **II** | **150,000** |
| 8 | 37 | Development and implementation of pilot projects on biogas production | **II** | **150,000** |
| 9 | 38 | Replacement of land-processing directions and technologies with the ones with low risk, to the extent possible | **II** | **200,000** |
| 9 | 39 | Development of forest protection zones in the agricultural land areas of the river basin | **II** | **250,000** |
| 9 | 40 | Development of forest protection zone in the banks of the river | **II** | **250,000** |
| ***Measures within estimated rough budget of 300,000-500,000 USD*** | | | | |
| 7 | 35 | Development of Environmental Management System for the industries in Marmarik River Basin in the line with the requirements for water ecosystems | **III** | **400,000** |
| 10 | 41 | Implementation of reforestation activities in the river basin, perspective and mass expansion of forest cover in the basin | **III** | **450,000** |
| ***Measures within estimated rough budget of 500,000-1,000,000 USD*** | | | | |
| 1 | 26 | Installation of drinking water treatment stations | **IV** | **700,000** |
| 1 | 27 | Rehabilitation of drinking water supply systems, including water intake structures, transmission and distribution pipelines, daily regulatory reservoirs, and house connections | **IV** | **900,000** |

| *Measures within estimated rough budget of over 1,000,000 USD* | | | | |
|---|---|---|---|---|
| 5 | 32 | Rehabilitation of the two reservoirs (Meghradzor and Marmarik) in the basin | **V** | **5,000,000** |
| 8 | 36 | Construction of local wastewater treatment facilities in the river basin for large communities, hotels, resorts, as well as large farms | **V** | **1,500,000** |
| | | **Total** | | **10,200,000** |

## *Conclusions and Recommendations*

As seen from the previous sections, the overall financing required for implementation of all the measures is approximately almost 12 million USD. Most of the calculated cost is associated with implementation of the technical measures (about 10 million USD). This is due to the fact that most of the technical measures require large-scale infrastructure works (construction of reservoir, local wastewater treatment facilities, rehabilitation of drinking water systems, installation of drinking water treatment stations, and others).

The table below provides combined information of preliminary cost estimates of the proposed legal, institutional and technical measures for Marmarik River basin. The cost estimate also provides information on finances required to achieve priority target directions.

*Table 18: Preliminary cost estimate of proposed measures*

| **Desired Conditions** | **Priority** | **Target Directions** | **Legal Measures, No** | **Budget** | **Institutional Measures, No.** | **Budget** | **Technical Measures, No.** | **Budget** | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| Quantity | Drinking-Household | 1 | 1 | **50,000** | 15 | **75,000** | 25 | **150,000** | **1,875,000** |
| | | | | | | | 26 | **700,000** | |
| | | | | | | | 27 | **900,000** | |
| | Hydrological Reserve | 2 | 2 | **60,000** | 16 | **200,000** | 28 | **150,000** | **410,000** |
| | Recreation Zone | 3 | 3 | **30,000** | 17 | **25,000** | 29 | **20,000** | **110,000** |
| | | | | | | | 30 | **35,000** | |
| | Hydroenergy | 4 | 4 | **50,000** | 18 | **10,000** | 31 | **10,000** | **70,000** |
| | Irrigation | 5 | 5 | **200,000** | 19 | **15,000** | 32 | **5,000,000** | **5,225,000** |
| | | | | | | | 33 | **10,000** | |
| | | 6 | 6 | **50,000** | 20 | **20,000** | 34 | **25,000** | **95,000** |
| | Industry | 7 | 7 | **200,000** | 21 | **15,000** | 35 | **400,000** | **645,000** |
| | | | 8 | **30,000** | | | | | |
| Quality | Water Quality Protection | 8 | 9 | **250,000** | 22 | **15,000** | 36 | **1,500,000** | **1,930,000** |
| | | | 10 | **15,000** | | | 37 | **150,000** | |
| | | 9 | 11 | **150,000** | 23 | **15,000** | 38 | **200,000** | **905,000** |
| | | | 12 | **15,000** | | | 39 | **250,000** | |
| | | | 13 | **25,000** | | | 40 | **250,000** | |
| | | 10 | 14 | **25,000** | 24 | **15,000** | 41 | **450,000** | **490,000** |
| | | | **Total** | **1,150,000** | **Total** | **405,000** | **Total** | **10,200,000** | **11,755,000** |

# PUBLIC INVOLVEMENT IN DECISION MAKING

## *Identification of Issues Requiring Public Consultations*

Water resources have significant importance for socio-economic development of both Marmarik River Basin and the Republic of Armenia. Naturally, water sector problems and issues, development trends and desired conditions for water uses and functions, mentioned in the previous sections should contribute to the well-being of the population in the river basin. Thus, the desired conditions should help in solving social issues, provide for basic requirements, contribute to poverty reduction, and of course add in to the overall economy development in Marmarik River Basin.

Hence, in order to have the right direction of integrated water resources management it is necessary to obtain the public opinion on the above-mentioned issues. For that purpose a field survey questionnaire for Marmarik River Basin was been developed, which was presented to local population, as well as representatives of local self-governance authorities.

The questionnaire included general information on respondents (name, community, age, specialization, main source of income), as well as their perception on the water sector in the river basin, including suggestions and observations. The main topics covered in the questionnaire related to water-related disasters in Marmarik River Basin, water use, water quantity, water quality, as well as water resources management and public participation in decision making.

The purpose of the section on “Water-related disasters” was to obtain detailed information on water-related disasters in the basin, their type, frequency of occurrence, extent, as well as damage caused to households and infrastructures.

In the section “Water Use” of the questionnaire the issues related to water use, proposals on rational use and perception of respondents on priority water uses were covered.

The section “Water quantity” aimed to clarify whether the quantity of drinking, irrigation and other waters is sufficient, the existence of seasonal variations, as well as their tendencies.

The section “Water quality” covered issues related to drinking, irrigation, and other water quality, dynamics of water quality change, as well as existence of water related diseases.

The last section of the questionnaire aimed to obtain the opinion of respondents on where the water management authorities should pay their attention, and what are the necessary steps to undertake in order to improve the overall water management in Marmarik River Basin. Possible mechanisms of public participation in decision making and related issues were also discussed.

The questionnaire was distributed to the local population with an effort to include all representative groups in each rural community, to the extent possible. In addition to that, slightly revised questionnaire was submitted to the representatives of local self-governance authorities (e.g. rural community heads, specialists of regional administration. etc) and representatives of BMOs, WUAs and major water users in the basin, including the industries.

The samples of the questionnaires are presented in the annexes of this report.

## *Analysis of Stakeholder Consultations and Field Survey Results*

The field survey included 200 respondents, including 170 residents of Marmarik River basin communities (representing all the communities in the basin), as well as 30 major water users, representatives of local self-governance authorities and decision makers in the basin.

### Water Related Disasters

The survey included several questions on water-related disasters. About 77% of respondents mentioned that the main water-related disasters are the mudflows and flooding, whereas 8% of the respondents mentioned that there are no water related disasters in the basin.

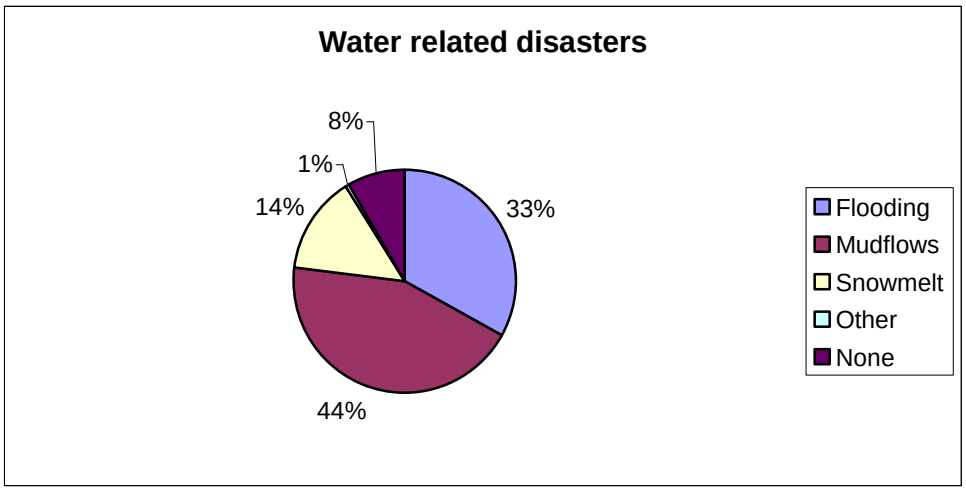


*Figure 7: Water related disasters in Marmarik River basin*

According to respondents the main damage caused due to water related disasters included farms adjacent to houses (35%), plough land (27%), infrastructure (15%) and livestock (15%).

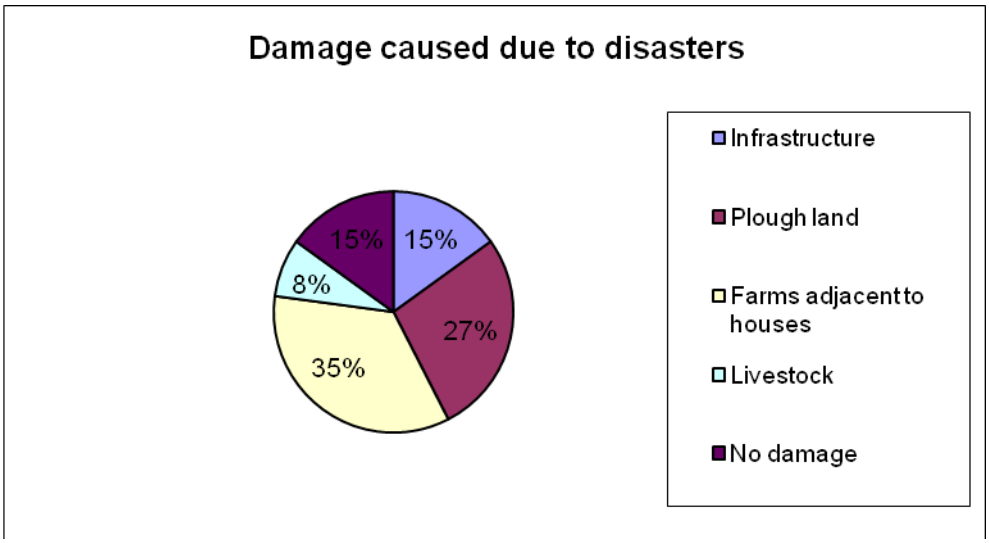


*Figure 8: Damage caused due to water related disasters in the basin*

However, most of the residents (about 77%) found it difficult to estimate the damage of water related disasters. 23% of the respondents mentioned various levels of damage, which on average composed about 2.5 million AMD (over 8300 USD) per household.

According to 65% of respondents the frequency of occurrence if water related disasters in Marmarik River basin is high, whereas 16% of surveyed residents claim that there is either rare or no occurrence of water related disasters in the basin during the last five years.

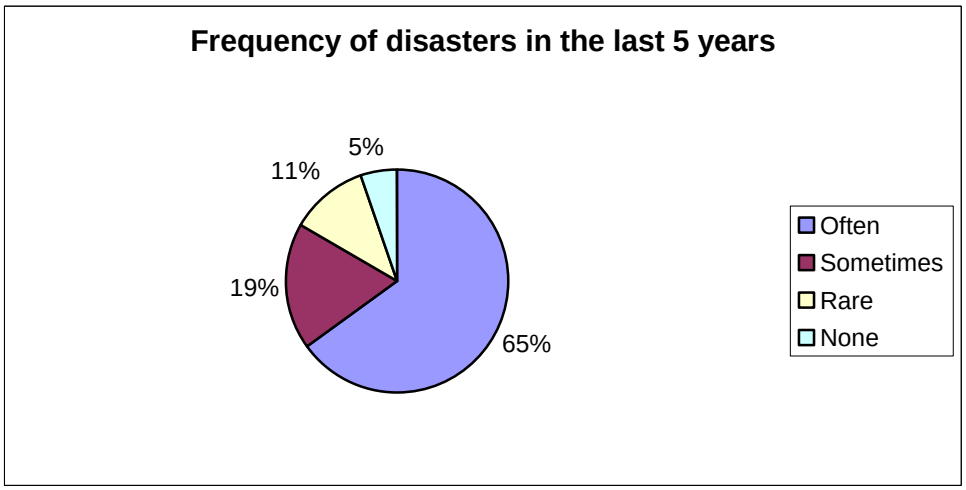


*Figure 9: Frequency of disasters in the basin during the last 5 years*

As for measures to cope with water-related disasters, the survey participants proposed water discharge (37%), flood control structures (36%) and regulation of flow (26%), including construction of reservoirs.

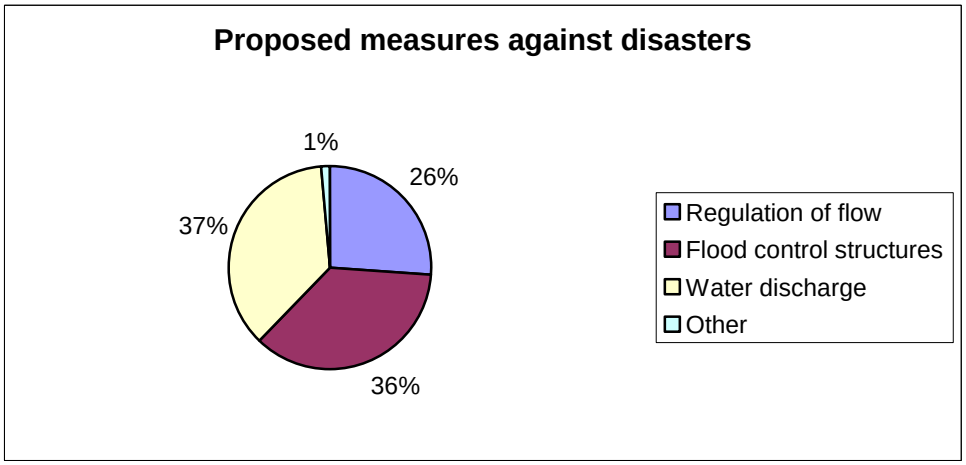


*Figure 10: Proposed measures to cope with water related disasters in Marmarik River basin*

## Water Use

Water use efficiency issues were also included in the field survey. About 29% of the respondents stated that water resources are being used not rationally in Marmarik River basin, whereas 28% claimed that they are being used mainly rationally. A significant number of respondents (23%) found it difficult to assess the water use efficiency. 12% of respondents think that water is being used rationally. However, about 8% of survey

participants claimed that water resources in the basin are being used in highly non-rational manner.

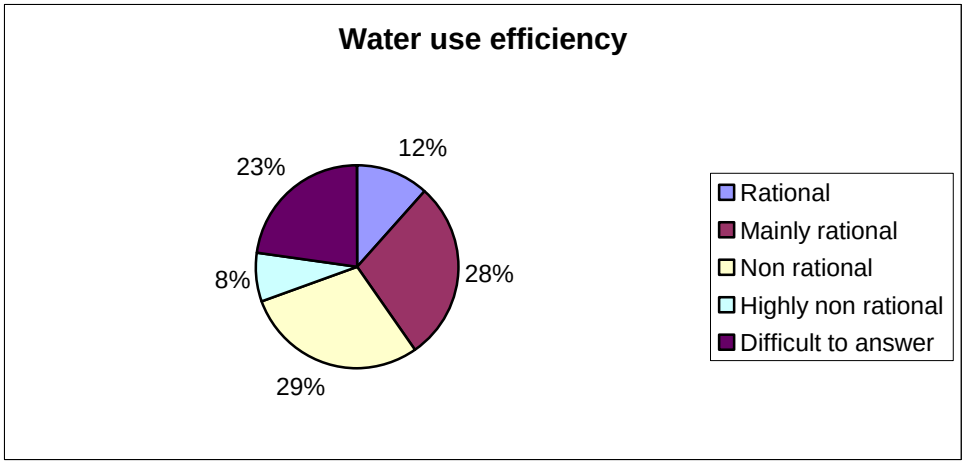


*Figure 11: Water use efficiency in the basin*

64% of the respondents proposed regulation of water flow including construction of dams, as a way to promote rational water use. 25% proposed introduction of water saving technologies, including introduction of drip irrigation. Finally, 9% of respondents proposed installation of water meters both for drinking and irrigation water use as a mean of promoting rational water use.

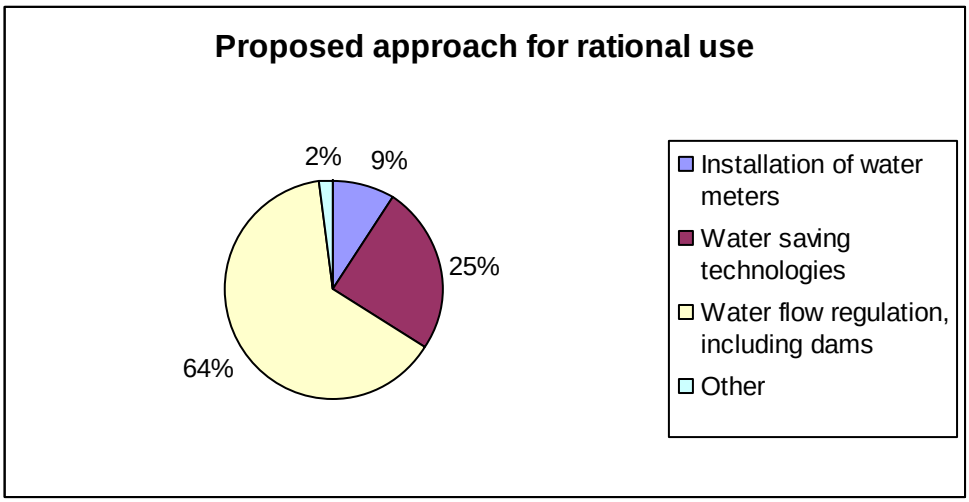


*Figure 12: Proposed approaches for promoting rational water use in Marmarik River basin*

Finally, regarding the water use priority in the river basin the following results are obtained. 52% prioritize water use for drinking-household purposes, 36% prioritize water use for irrigation and 7% prioritize water use for recreational purposes.

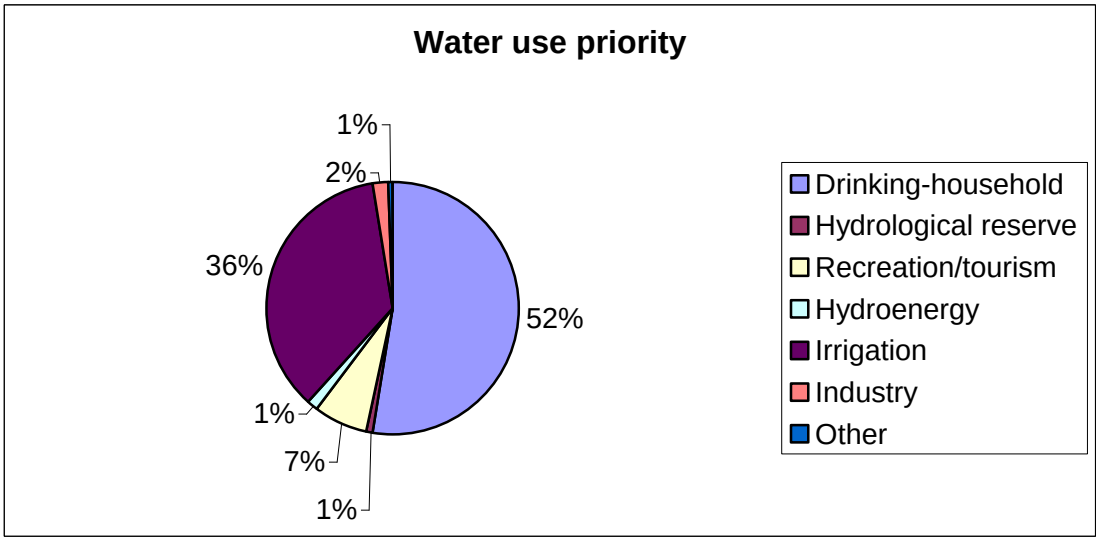


*Figure 13: Water use priorities in Marmarik River basin*

## Water Quantity

According to survey results the quantity of drinking water in the basin is not sufficient. About 52% of respondents considered drinking water quantity insufficient, whereas 31% mentioned that drinking water quantity is only partially sufficient.

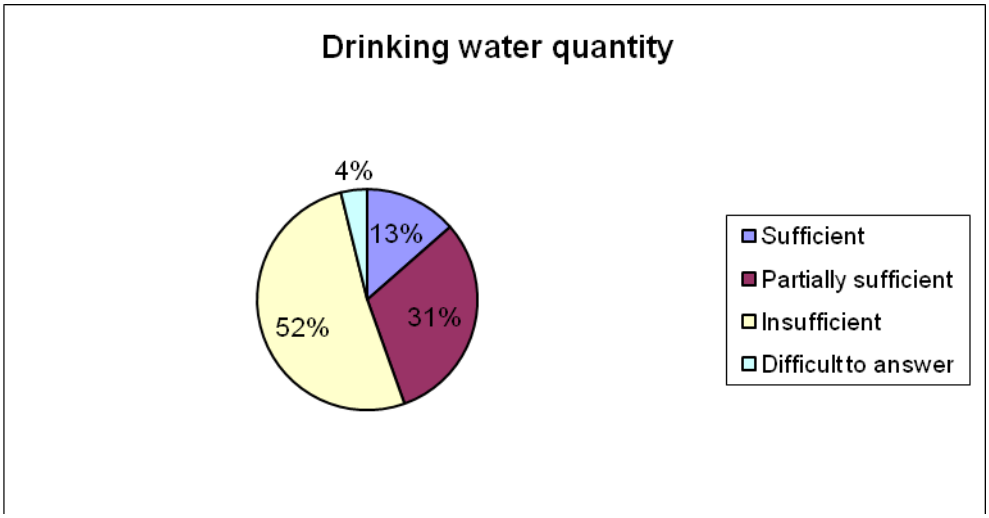


*Figure 14: Drinking water quantity in Marmarik River basin*

Almost half of the respondents (49%) mentioned that there are seasonal variations in drinking water availability, whereas 30% claimed there are no seasonal variations. About 21% of survey participants found it difficult to answer to questions.

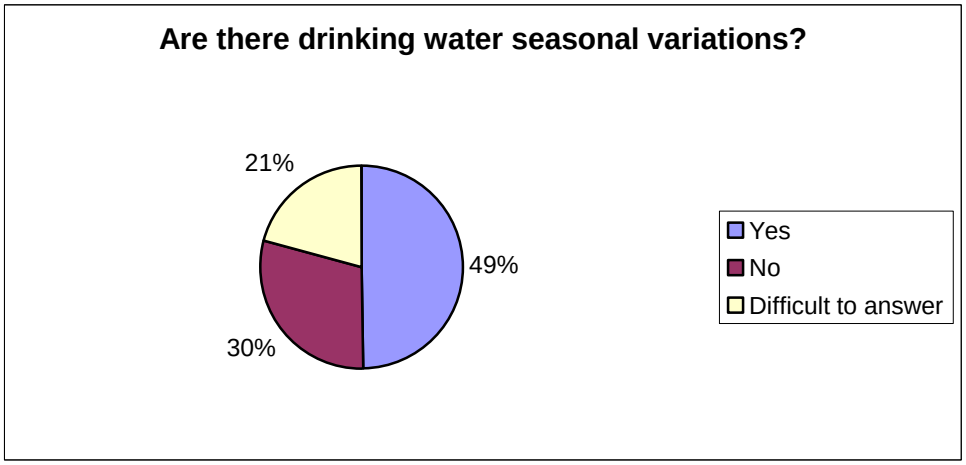


*Figure 15: Assessment of drinking water seasonal variations in the basin*

Of those, who claimed that there are drinking water seasonal variations, consider that the main drinking water deficit season is summer (61%) and winter (23%). Correspondingly 9% and 7% of respondents mentioned that drinking water deficit season is fall and spring.

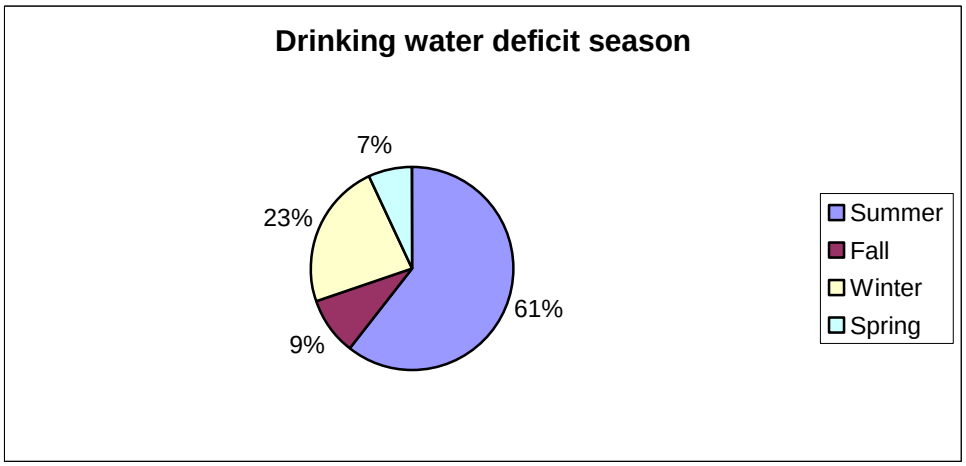


*Figure 16: Drinking water deficit seasons in Marmarik River basin*

There is also a significant shortage of irrigation water in Marmarik River basin. Thus, 63% of respondents claim that irrigation water quantity is insufficient, and 17% claim that it is only partially sufficient. Only 8% of the respondents mentioned that irrigation water quantity in the basin is sufficient.

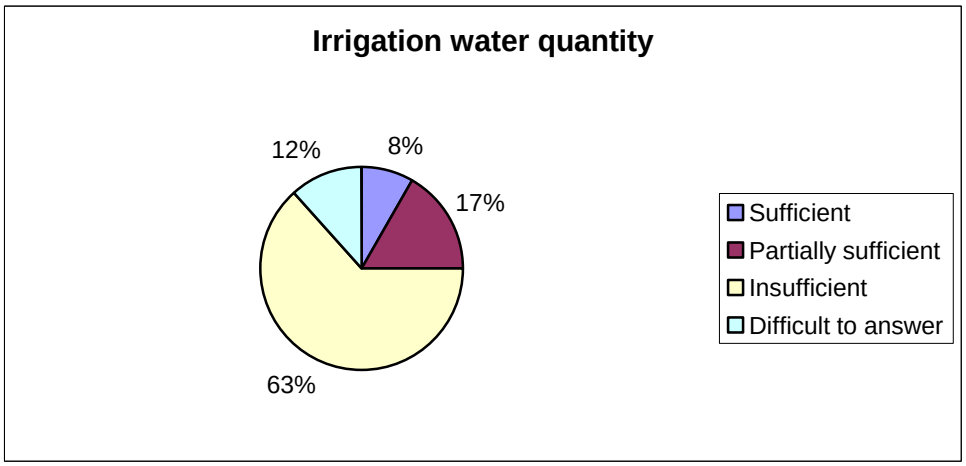


*Figure 17: Irrigation water quantity in the basin*

About 74% of the survey participants claimed that there are irrigation water seasonal variations, and only 4% claimed that there are no seasonal variations in terms of irrigation water availability.

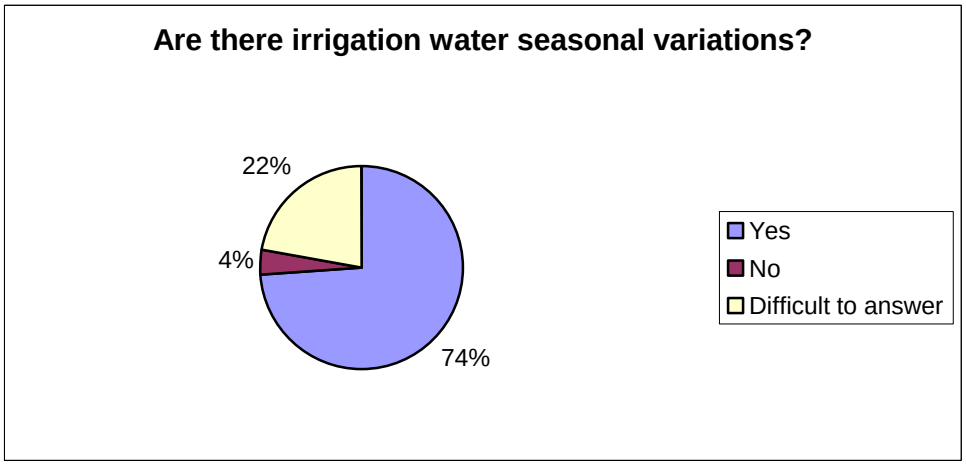


*Figure 18: Seasonal variations in availability of irrigation water*

Of those who claimed that there are irrigation water seasonal variations, 82% mentioned that the main deficit season is summer, which is the peak season of irrigation in the river basin. 10% of the respondents mentioned spring as deficit season, and 5% and 3% - correspondingly fall and winter.

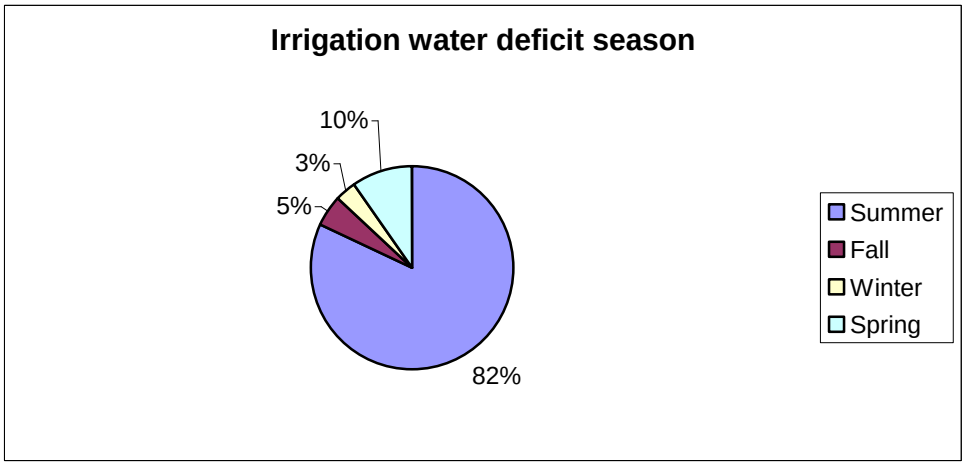


*Figure 19: Irrigation water deficit seasons in the basin*

## Water Quality

In addition to water quantity, there are also some issues related to water quality in Marmarik River basin. About 55% of respondents mentioned that the drinking water quality is not always satisfactory, whereas 20% claimed that the quality of drinking water is mainly satisfactory.

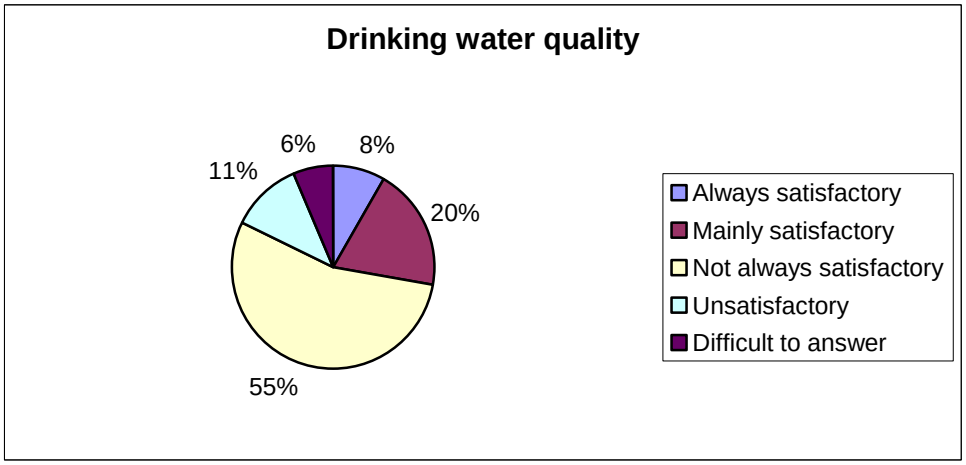


*Figure 20: Quality of drinking water in the basin*

Half of the survey participants mentioned that there are seasonal variations in drinking water quality, whereas 29% claimed there are no variations in quality, and 21% found it difficult to answer.

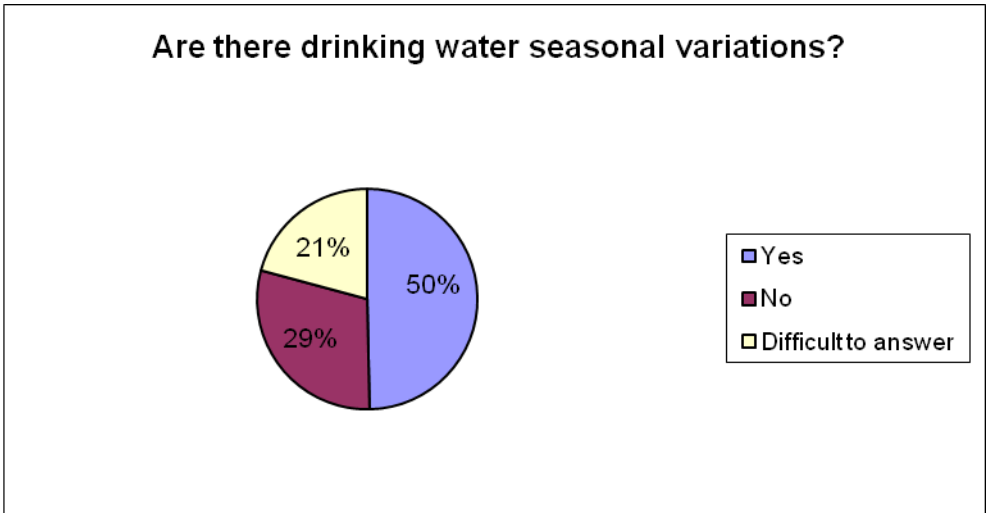


*Figure 21: Seasonal variations in drinking water quality*

36% of the respondents claimed that most of the water quality problems occur in spring, 20% in summer, 16% in fall, and 6% in winter. 22% of the survey participants found it difficult to answer.

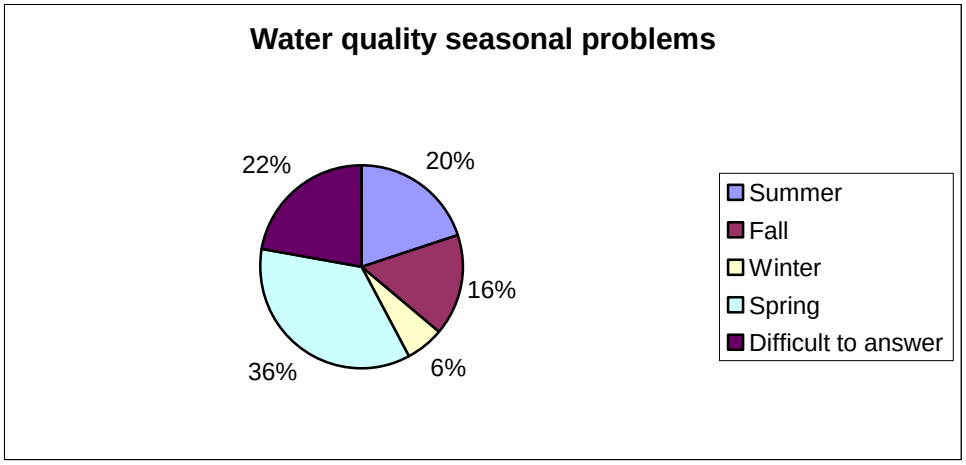


*Figure 22: Water quality seasonal problems in the basin*

About 28% of respondents mentioned that there are water related diseases in the basin, whereas 42% claimed there are no water related diseases, and 30% found it difficult to answer. According to survey participants the main water related diseases refer to diarrhea, intestinal and gastric diseases, and others.

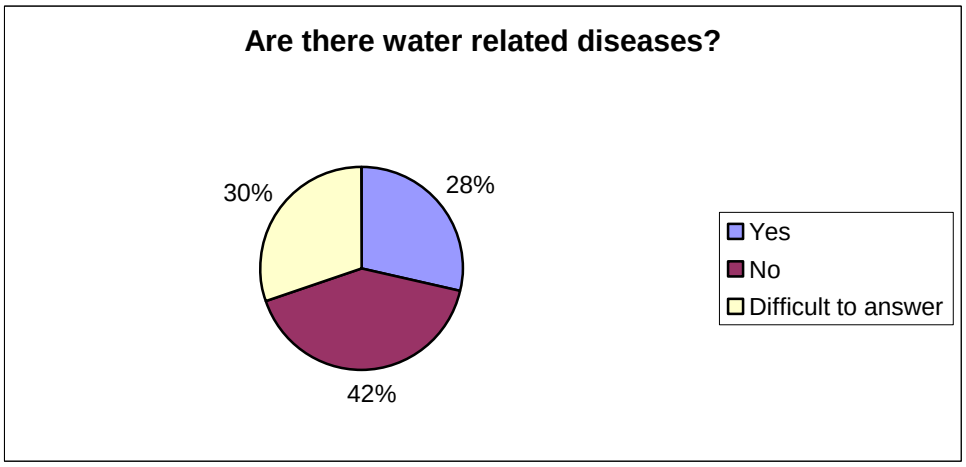


*Figure 23: Existence of water related diseases in the basin*

The situation is better for irrigation water quality. About 61% of the survey participants claimed that irrigation water quality is always (31% of respondents) or mainly (30% of respondents) satisfactory. 15% of the survey participants are not always satisfied with irrigation water quality. A significant number of respondents (about 22%) found it difficult to answer to question.

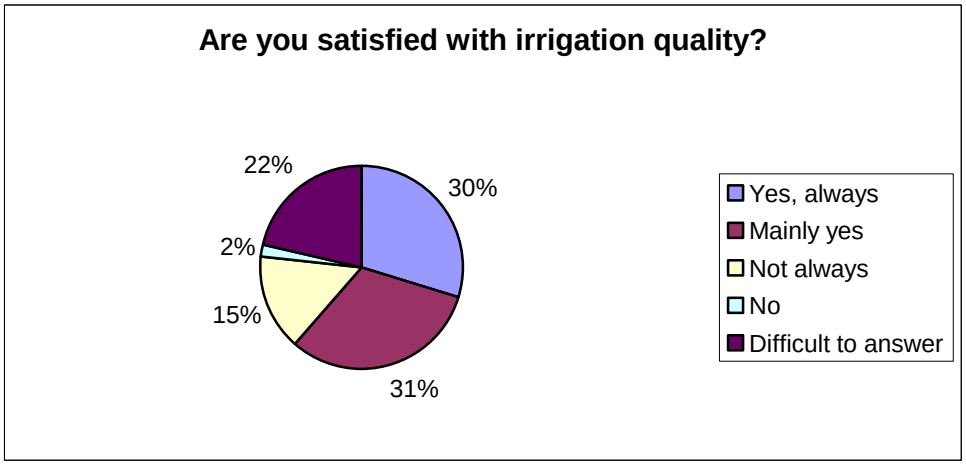


*Figure 24: Irrigation water quality in Marmarik River basin*

The main sources of water pollution in Marmarik River basin, according to survey results are: domestic waste (36%), wastewater (34%), industrial waste (12%) and livestock (11%).

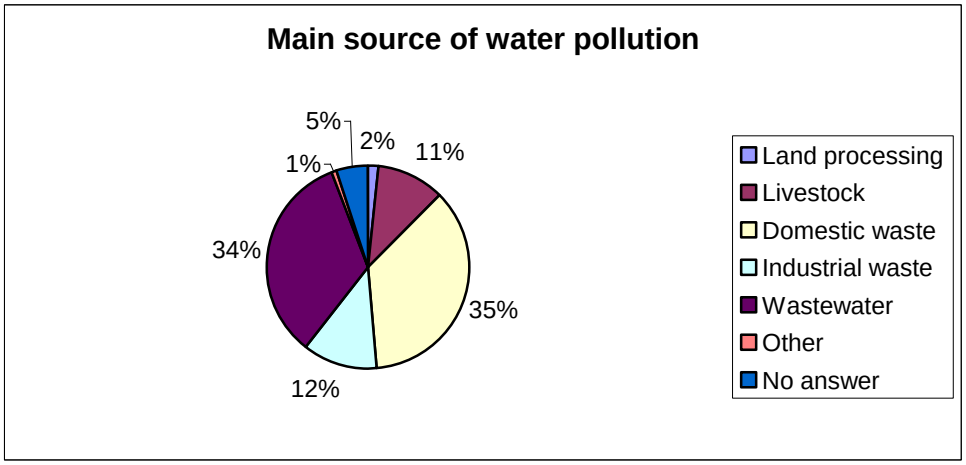


*Figure 25: Main sources of water pollution in the basin*

## Public Involvement

Public involvement issues in water sector were also surveyed in the field works and proposals were made to improve the situation in water sector in the basin, as well as mechanisms for involving public in decision making process.

The participants proposed the decision-makers in water sector to concentrate on the following areas: water quality (27%), water resources protection (19%), regulation of water flow (15%), water quantity (12%), water-related disaster prevention (11%), and rational water use (10%).

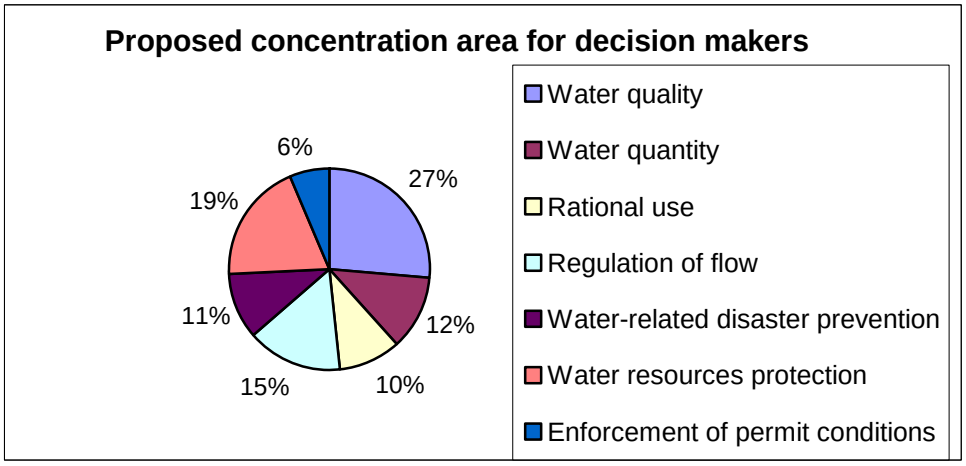


*Figure 26: Proposed concentration areas in Marmarik basin for water sector decision makers*

60% of survey participants mentioned that there is a need to involve more actively the public in decision-making in water sector. 15% of respondents considers that public is already actively involved in decision making and there is no need to make additional efforts.

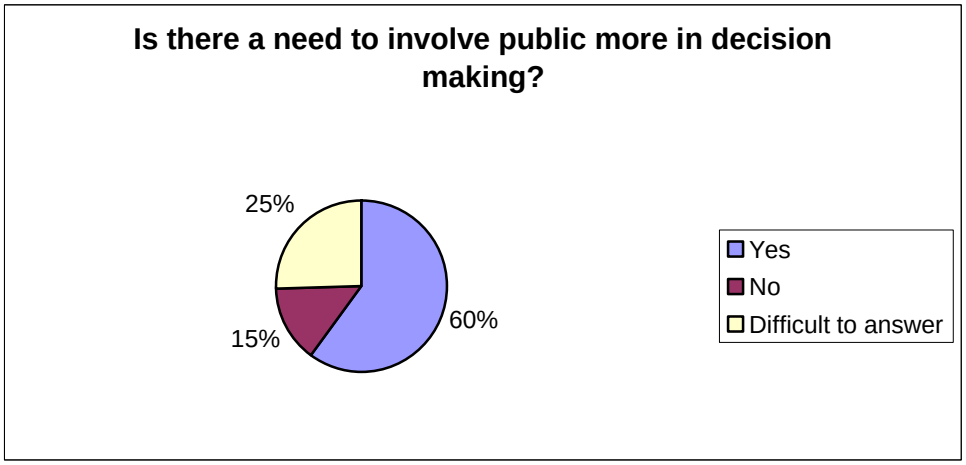


*Figure 27: Necessity to involve public more actively in decision making*

Finally, according to survey results the most common proposed ways to involve public in decision-making in water sector in Marmarik River basin are the following: public hearings (48%) and establishment of river basin council (21%).

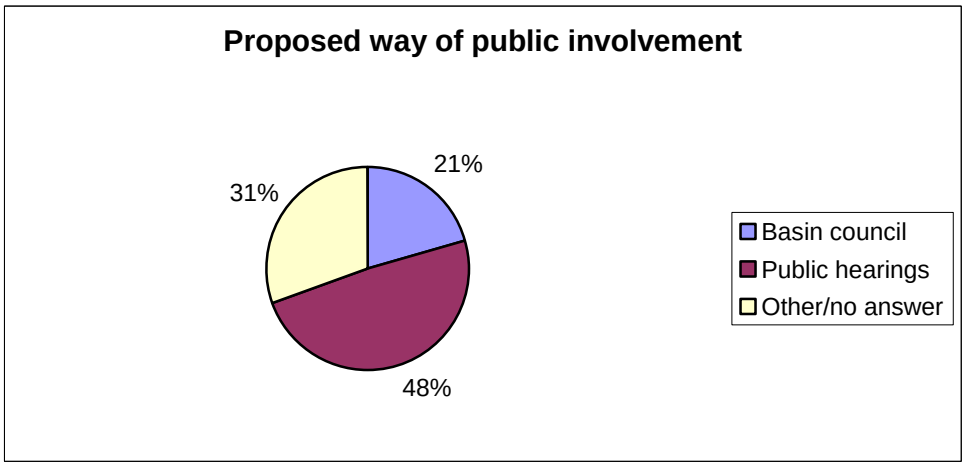


*Figure 28: Proposed ways of public involvement in decision making process in Marmarik basin*

## *Conclusions and Suggestions*

The results of field survey and consultations with local stakeholders show that the identified current problems and desired conditions are pretty much in line with findings and prioties of population in Marmarik River basin. Moreover, many of the propose legal, institutional and particularly technical measures address some of the priority concerns of local population.

In coping with water related disasters the majority of population proposed improvement of water discharge, construction and/or renovation of flood control structures and regulation of flow. As for approaches for promoting rational water use, all of the proposed priorities by the stakeholders (water flow regulation, including construction of dams, introduction of water saving technologies, and installation of water meters) are included in the list of technical measures.

About half of the respondents mentioned the problems related to drinking water quality. Even several cases of water related occurred. This might be due to the fact that drinking water is not chlorinated in many rural communities of the basin and the drinking water supply network is deteriorated. From this aspect both legal (minimum water quality requirements), institutional (options for operation and maintenance) and technical (rehabilitation of water supply systems) are proposed in the report.

Summarizing, it should be noted the the results of the field survey are found to be very important and all of the priority directions and concerns expressed by local population are taken into consideration while developing legal, institutional and technicial measures to achieve desired condition and water use in Marmarik River basin.

# ANNEX 1 – FIELD TRIP QUESTIONNNAIRE IN MARMARIK RIVER BASIN FOR LOCAL POPULATION

## *I. GENERAL INFORMATION*

Name _____

Community _____

Age and specialization _____

Number of household members _____

Main source of income _____

## *II. CONDITION OF WATER SECTOR IN THE RIVER BASIN*

### A. Disasters related to water resources

A1. Indicate the main water-related disasters

□ Floods □ Mudflows □ Snowmelt □ None □ Other _____

A2. Indicate the main damage caused by water-related disasters

□ Infrastructure □ Plough-lands □ Gardens □ Livestock
□ No damage □ Other _____

A3. Indicate the frequency of disasters in the recent 5 years

□ Often □ Sometimes □ Rarely □ None □ Other _____

A4. If water-related disasters in the last 5 years have causes damage to your economy, indicate the approximate magnitude

□ Single damage of _____ AMD □ Multiple damages of _____ AMD
□ Other _____ □ Difficult to answer

A5. Propose methods to cope with the above-mentioned disasters

□ Regulation of water flow □ Development of flood-control structures
□ Development of water discharge systems □ Other _____

### B. Water Use

B1. Your opinion on the water use in the river basin

□ Rational □ Mainly rational □ Non-rational □ Non-rational at all
□ Difficult to answer

B2. Propose an approach for rational water use

□ Installation of water-meters □ Introduction of water-saving technologies
□ Regulation of water flow, e.g. dam construction □ Other _____

B3. Indicate priority water use according to you (indicate only one)

□ Drinking-household □ Hydrological reserve □ Recreation
□ Hydroenergy □ Irrigation □ Industry
□ Other _____

B4. Categorize water use priority according to your judgment (priorities should be ranked I-VII)

Drinking-household _____
Hydrological reserve _____
Recreation _____
Hydroenergy _____
Irrigation _____
Industry _____
Other _____

**C. Water quantity**

***Drinking***

C1. Is drinking water quantity is enough?

□ Yes □ Partially □ No □ Difficult to answer

C2. Are there seasonal variations in water supply?

□ Yes □ No □ Difficult to answer

C3. For seasonal variations in water quantity, in which season the water quantity is not enough?

□ Summer □ Autumn □ Winter □ Spring

***Irrigation***

C4. Is irrigation water quantity satisfactory?

□ Yes □ Partially □ No □ Difficult to answer

C5. Are there seasonal variations in water supply?

□ Yes □ No □ Difficult to answer

C6. For seasonal variations in water quantity, in which season the water quantity is not enough?

□ Summer □ Autumn □ Winter □ Spring

***Other***

C7. Is the water quantity enough for other water uses (except to drinking and irrigation uses)?

□ Yes □ No □ Difficult to answer

**D. Water Quality**

D1. Is the drinking water quality satisfactory?

□ Yes, always □ Mainly yes □ Not always □ No □ Difficult to answer

D2. In which season drinking water quality is not satisfactory or not good quality?

□ Summer □ Autumn □ Winter □ Spring □ Difficult to answer

D3. Has there been any case of drinking water-related disease or infection (if yes, please mention the details)

□ Yes _____
□ No
□ Difficult to answer

D4. Is irrigation water quality is satisfactory?

□ Yes, always □ Mainly yes □ Now always □ No □ Difficult to answer

D5. Indicate the pollution sources of water resources according to you

□ Land-processing □ Livestock-breeding □ Household waste □ Industrial waste □ Wastewater
□ Other _____

**E. Water resources management and public participation**

E1. Which area the water management authority should concentrate on?

□ Water quality □ Water quantity □ Promotion of rational water use
□ Regulation of water flow □ Prevention of water-repeated disasters
□ Water resources protection □ Control of water use conditions
□ Other _____

E2. Is there a need to include public into decision making on water resources management more frequently?

□ Yes □ No □ Difficult to answer

E3. Propose mechanisms for involving the public more actively in solving water sector problems?

□ Establishment of river basin public council
□ Organization of public hearings on important water sector issues
□ Other

E4. Provide additional comments and observations on the topic

_____

_____

_____

_____

# ANNEX 2 – FIELD TRIP QUESTIONNNAIRE IN MARMARIK RIVER BASIN FOR SELF-GOVERNANCE AUTHORITIES AND MAJOR WATER USERS

## *I. GENERAL INFORMATION*

Name _____

Community _____

Organization _____

Position _____

## *II. CONDITION OF WATER SECTOR IN THE RIVER BASIN*

**A. Disasters related to water resources**

A1. Indicate the main water-related disasters

□ Floods □ Mudflows □ Snowmelt □ None □ Other _____

A2. Indicate the main damage caused by water-related disasters

□ Infrastructure □ Plough-lands □ Gardens □ Livestock
□ No damage □ Other _____

A3. Indicate the frequency of disasters in the recent 5 years

□ Often □ Sometimes □ Rarely □ None □ Other _____

A4. If water-related disasters in the last 5 years have causes damage to your economy, indicate the approximate magnitude

□ Single damage of _____ AMD □ Multiple damages of _____ AMD
□ Other _____ □ Difficult to answer

A5. Propose methods to cope with the above-mentioned disasters

□ Regulation of water flow □ Development of flood-control structures
□ Development of water discharge systems □ Other _____

**B. Water Use**

B1. Your opinion on the water use in the river basin

□ Rational □ Mainly rational □ Non-rational □ Non-rational at all
□ Difficult to answer

B2. Propose an approach for rational water use

□ Installation of water-meters □ Introduction of water-saving technologies
□ Regulation of water flow, e.g. dam construction □ Other _____

B3. Indicate priority water use according to you (indicate only one)

□ Drinking-household □ Hydrological reserve □ Recreation
□ Hydroenergy □ Irrigation □ Industry
□ Other _____

B4. Categorize water use priority according to your judgment (priorities should be ranked I-VII)

Drinking-household _____
Hydrological reserve _____
Recreation _____
Hydroenergy _____
Irrigation _____
Industry _____
Other _____

**C. Water quantity**

***Drinking***

C1. Is drinking water quantity is enough?

□ Yes □ Partially □ No □ Difficult to answer

C2. Are there seasonal variations in water supply?

□ Yes □ No □ Difficult to answer

C3. For seasonal variations in water quantity, in which season the water quantity is not enough?

□ Summer □ Autumn □ Winter □ Spring

***Irrigation***

C4. Is irrigation water quantity satisfactory?

□ Yes □ Partially □ No □ Difficult to answer

C5. Are there seasonal variations in water supply?

□ Yes □ No □ Difficult to answer

C6. For seasonal variations in water quantity, in which season the water quantity is not enough?

□ Summer □ Autumn □ Winter □ Spring

***Other***

C7. Is the water quantity enough for other water uses (except to drinking and irrigation uses)?

□ Yes □ No □ Difficult to answer

**D. Water Quality**

D1. Is the drinking water quality satisfactory?

□ Yes, always □ Mainly yes □ Not always □ No □ Difficult to answer

D2. In which season drinking water quality is not satisfactory or not good quality?

□ Summer □ Autumn □ Winter □ Spring □ Difficult to answer

D3. Has there been any case of drinking water-related disease or infection (if yes, please mention the details)

□ Yes _____
□ No
□ Difficult to answer

D4. Is irrigation water quality is satisfactory?

□ Yes, always □ Mainly yes □ Now always □ No □ Difficult to answer

D5. Indicate the pollution sources of water resources according to you

□ Land-processing □ Livestock-breeding □ Household waste □ Industrial waste □ Wastewater
□ Other _____

**E. Water resources management and public participation**

E1. Which area the water management authority should concentrate on?

□ Water quality □ Water quantity □ Promotion of rational water use
□ Regulation of water flow □ Prevention of water-related disasters
□ Water resources protection □ Control of water use conditions
□ Other _____

E2. Is there a need to include public into decision making on water resources management more frequently?

□ Yes □ No □ Difficult to answer

E3. Propose mechanisms for involving the public more actively in solving water sector problems?

□ Establishment of river basin public council
□ Organization of public hearings on important water sector issues
□ Other

E4. Provide additional comments and observations on the topic

_____

_____

_____

_____