Natural Capital Project Armenian Pilot: Mainstreaming Natural Capital Approaches into the Ararat River Basin Management Plan – Armenia

Economic Valuation Across Sectors

Technical Report

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1. About the project

The overall objective of this intervention is to integrate the Natural Capital approaches into the river basin management plans (section on natural capital & ecosystem services) and relevant strategic documents (e.g., strategic environmental impact assessment) which will then help national resources management as well as alignment with other international partners (e.g., EU-WFD).

In a long-term perspective, this will help to increase appropriate investments into sustainable watershed development based on science-based information, also supporting water security at the river basin level.

The report is developed in scopes of **Task 3** and **Task 4** assigned to the consulting company. Underlying data are presented in SI Database 3.1.

Task 3. Conducting sociological surveys in Ararat BMA to assess the importance of ecosystem services for particular stakeholder groups (civil society – 3-4 representatives of local NGOs, local businesses (including owners/co-owners of 3-4 fish-farms, owners/co-owners of 3-4 hydropower plants, 3-4 farmers, owners/co-owners of 3-4 recreational objects such as restaurants, hotels, etc.), local government (heads of 5 pre-selected communities), etc.).

Task 4. Developing a framework for assessing the values of ecosystem services in monetary terms in Ararat BMA, by evaluating the availability of data required to apply economic valuation methods, e.g., market value analysis, avoided damage costs, contingent valuation, etc., and developing a roadmap for valuing natural capital in the basin for application in future studies.

2. Selecting the Ecosystem Services for Economic Valuation

Water resources have key importance for many sectors of economy such as food and beverage production, hydroelectricity generation, recreation, and different sectors of agriculture such as fish farming, land cultivation, animal husbandry, etc. Considering the scope of the current study, firstly we shortlisted the sectors of the economy where water is the main input for production, which are: **Land Cultivation, Fish Farming a**nd **Hydroelectric Power Plants (HPP) Operation.**

HPPs have a significant importance for the energy-security of the country, and in the case of sustainable management, the Hydropower could serve as a source of "green energy". However, in Armenia, Hydropower generation unfortunately cause conflict of interest with other sectors, in particular, with land cultivation.

Despite the fact that both the HPPs and fish farms are not supposed to consume water, both sectors are acknowledged by farmers to cause scarcity of water. Hydropower sector is well developed in Vayots Dzor region, while fish farms are widespread in Ararat region.

In land cultivation, there is a wide range of sub-sectors, such as cultivation of technical crops, forage, melon crops, leguminous crops, potato, vegetable crops, melon crops, fruit orchards, berry fields and vineyards, etc.

To select the crop types for the analysis in the frames of this study, in a first run, the area under cultivation of each crop group was used as an indicator. Six crop groups were selected which are popular in Ararat and Vayots Dzor regions: 1. vegetable crops, 2. melon crops, 3. grains and legumes, 4. potato, 5. fruit and berries, 6. Grapes.

Three indicators were used for further shortlisting of the crop groups for this study:

- Share of the area under cultivation of each crop group in the total area of land cultivation in the region.
- Share of agricultural output in weight of each crop group in the total agricultural output of the sector for Armenia.
- Share of gross output for each crop group in AMD in the total gross output of land cultivation in AMD.

Statistical committee of Armenia does not publish information about the structure of gross agricultural output in region level, and we must estimate it by doing some calculations: in particular, firstly, the monetary value of each of the sectors of agriculture was weighted (Table A, Annex 1). Afterwards, using the information of the share of gross output of each of the sectors in the agricultural output of the region, the approximate monetary value of output for each of the sectors in region level was weighted. (Table B and C, Annex 1). After having these calculations, the rating of the crop groups of study was summarized, which is presented in Table D, Annex 1. As a result of the analysis, for the further study three crop groups of land cultivation were selected: **vegetable crops, fruits and berries,** and **grape.**

3. Sociological surveys within different stakeholder groups on ecosystem services importance in the Ararat BMA

3.1 Methodology

In general, the stakeholders were grouped into two major sectors: a) profit-oriented sector (farmers engaged in different sectors of agriculture /land cultivation, gardening, etc./, businesses /fish farms, hydropower plants, recreational objects, etc./), b) non-profit oriented sector (local NGOs, LSGBs, region administration etc.).

In order to ensure the full geographical coverage of the survey, different stakeholders representing all the enlarged communities of Ararat and Vayots Dzor regions were engaged in the interviews.

In Vayots Dzor region, meetings were held in the Areni, Yeghegnadzor, Yegegis, Vayk, and Jermuk communities. In Ararat region, meetings were held in Artashat, Ararat, Masis, and Vedi communities.

In both regions, the interviews included non-profit oriented sector such as representatives of region administration bodies (Marzpetaran), the local self-governance bodies, and water user associations (WUAs).

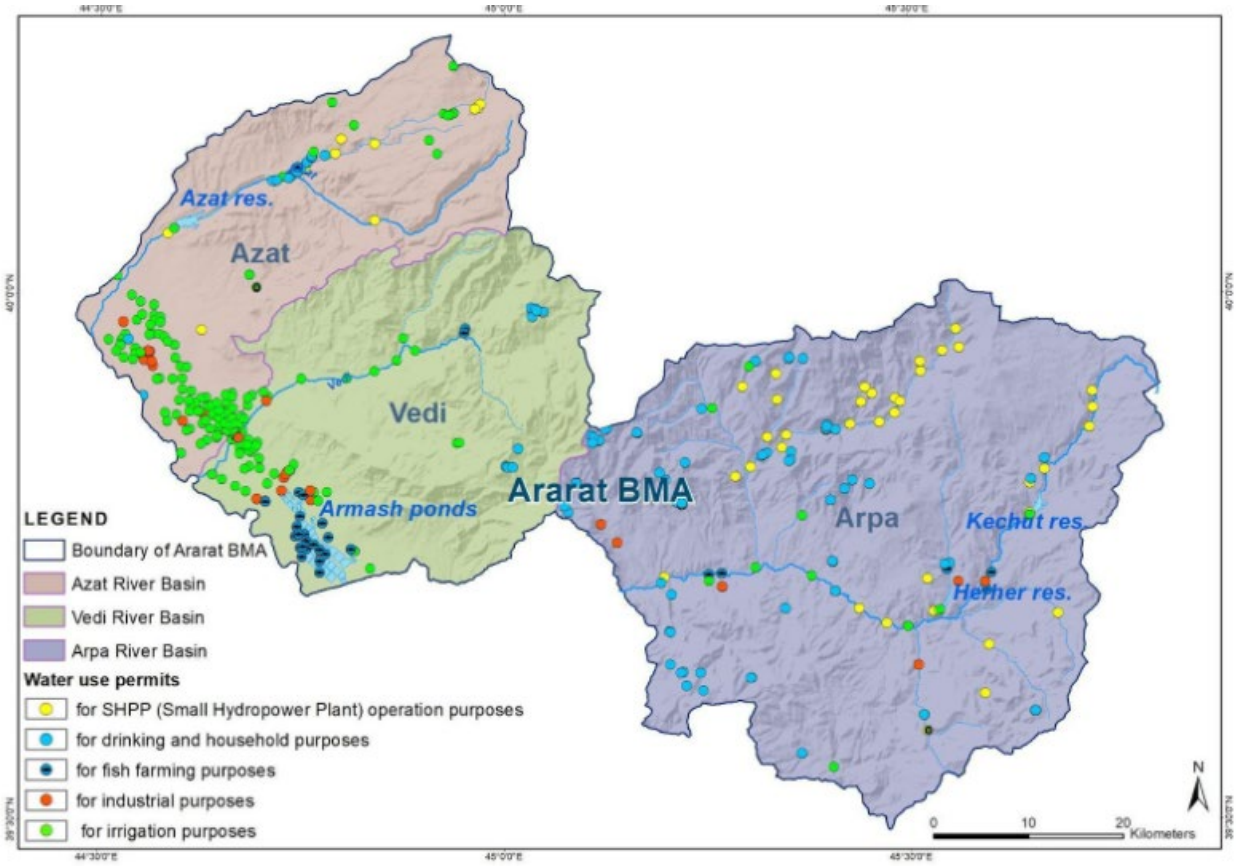
The selection of the respondents representing different sectors was based on the geospatial data on the locations on water use permits according to sectors. Intense accumulation of water use permits for irrigation in some region resulted in selecting more respondents in horticulture from that region. The information on the geographical distribution of different sectors was cross-checked with the

respondents of non-profit oriented sector and the selection of the respondents was based on "specialization" of the region. (e.g. for farmers in viticulture were selected from Areni community and more farmers in fruit growing were selected from Yegheghnadzor community).

During the field visits several attempts were undertaken to conduct interviews with the representatives of HPP in Vayots Dzor and fish farms in Ararat, since all the attempts were unsuccessful and none of the approached 5 HPPs and 4 fish farmers agreed to answer to any question.

Interviews with other stakeholders as well as information from different sources were used for collecting information about the activity of fish farms and HPPs. The distribution of the water use permits according to type of activiy is presented in the Figure 1.

Figure 1. The distribution of allowances for water use according to types of activity.



3.2 The key findings of the survey

Water resources/management problems (water quality, water use conflicts, etc.). identified through the survey

The conducted interviews indicate that the situation is very different in Ararat and Vayots dzor regions in regard to the quality and accessibility of water and is similar in terms of inefficient use of water.

Feedback of the respondents regarding the quality and accessible quantity of water was the main difference. For Ararat region, almost all the respondents have complained on the quality of water, in particular littering of water with solid waste, domestic wastewater and wastewater generated from animal husbandry (pig farming, cattle breeding and poultry) and are seriously to be anxious about the future accessibility of water, while in Vayots Dzor region, the respondents are mainly satisfied with the quality of water and don't see any reason to worry about potential shortage of water.

The main similarities and differences among the regions in management of water in horticulture are presented in below Table E, Annex 2.

Fish Farming

In recent years the Fish Farming has dramatically suffered because of several factors, such as epidemic outbreak, limited potential for exports because of international developments as well as changes in the policies and regulations related to Fish Farming.

The government has accepted regulations according to which was increased the requirements of the water use efficiency (annual amount of fish to be produced with use of 1 l/second water), because of which many fish farms being unable to meet the standards have stopped their activity.

The Fish Farming in Ararat river basin and in Hrazdan river basin is tangibly different. Hrazdan river basin is used basically for production of high value fish breed as trout and sturgeon, while the Ararat river basin is used for production of low value fish breeds such as different breeds of carp. The reason is that the trout and sturgeon are more sensitive towards the quality of water, in particular the temperature of the water and the oxygen content and the waters of Ararat water basin are not suitable in this regard.

The surveys indicate as well that the destiny of fish per cubic meter of water is lower in Ararat river basin, rather than in Hrazdan river basin. This is conditioned with the fact that in Ararat river basin fish breading is organized mainly in artificial water ponds with application of "nature-based solutions", while in Hzadan river basin fish breading is organized in basins with application of more industrial technologies.

The water saving technologies may be applied for increasing the efficiency of water usage in fish farming, but some respondents consider that such technologies have as well disadvantages such as:

- Increased communal (electricity) costs and increase cost price fish, making it non-competitive in international market.
- Investment of water saving technologies requires tangible investments with log pay-back period and in terms of existing uncertainties of the exporting opportunities it's very risky for the fish farmers to make such investments.
- "Closed" water management systems are much more sensitive towards epidemic outbreaks, and require much more accuracy in applies technologies (e.g. amount of used feed or medicinal substances).
- The quality of water is changed while being used in close systems, what negative impact on the quality of the product, in particular its taste.

Several respondents consider that in contrast to Horticulture, communal or animal husbandry, in fish farming the water is "used" and not "consumed". And water used in Fish Farming may be furthermore be used in Horticulture and even be more effective due to being enriched with useful bacteria.

Several respondents consider that despite existing conflict of interest among the Fish Farming and other sectors of economy, in case of good planning and sustainable management Fish Farming and Horticulture can even mutually contribute to each other development. As a good scenario of development of Fish Farming in Armenia is construction of water ponds, and close to that ponds establishment of fish farms which may use the water outflowed from the ponds, after which it will be supplied for irrigation of horticulture farms.

On the other hand, many respondents in Horticulture consider that currently Fish Farming is in a serious conflict of interest with Horticulture. Many interviewed farmers complain not only on the reduced quantity but on the reduced quality of water because of activity of fish farms. The

respondents consider that the water used in fish farms becomes saturated with microbes and bacteria from fish feed which is harmful for the gardens. Besides that, because of saturation with microbes and bacteria from fish farms the water harms the irrigation infrastructure, which gets mossy, what decreased the speed of water flow. Farmers consider that using water for fish farms causes increase of salination of water, which harms the soil. In some cases, the water turns to become fish-smelling and they believe that this fact dramatically impacts on the quality of agro product, especially the vegetables.

HPPs

The interviews conducted with different stakeholders in Vayots Dzor region indicate that despite the fact that the HPP have an approval of Environmental Impact Assessment, actually the activity of the HPP have very serious negative impact on the water ecosystems of the region. One of the main problems is related to equipping the HPP with automotive system of management of industrial accidents, due to which the water automatically is flowing out from the HPP to a river when an accident happens. Since this system causes additional costs for the HPP as when the water in the system is drained, the it takes additional time and energy costs until the system will be refilled with water. Because of this the HHP often switch off the automotive system of management of industrial accidents and in the case of industrial accidents water may be blocked in the HPP for several hours resulting in drying of the river bed. Because of this on one hand the fauna and flora of the rivers suffers dramatically, on the other hand significantly suffers the water supply to the farmers. The farmers make different expenditures to get ready for irrigation the fields (e.g. transportation cost, employing workforce with daily payment…) according to the schedule agreed with the water supply union, and then have to wait for several hours until the industrial accident in the HPP will be fixed and water will continue to flow by the river bed. Temporary drying of the river beds causes additional problems for the water supply union as well. When the water flow in the river is interrupted this leads to outflow of water from the irrigation pipelines which are filled with air. When this happens, pumps of the water supply union for several hours work without water causing additional ineffective costs. The outflow of the water from the pipeline infrastructure causes as well decrease of pressure in the pipelines and slow down the flow of water.
The respondents have mentioned three main factors dramatically impacting on the efficiency of HPP.

a) By the laws and regulations of Armenia, the amount of water which may be used by HPPs is limited, while in international practice the amount of water which should be left in the river without entering the turbines of HPPs is regulated. This factor is essential especially for those years when the year is favorable and the water flows are very abundant and could be used by HPP for generation of energy, but because the law limits the amount of the water which could be used by HPP, the HPP don't use additional water which could be used for production of energy.

b) Because of lack of reservoirs, during spring overflowing water which could be collected and sustainably used by HPP and agriculture, is being wasted without creating any additional value.

c) The infrastructure of the electric networks of Armenia is in bad condition and not always is able to supply electricity to the HPP or accept electricity produced by the HPP. Often the HPP are requested not to produce electricity because it cannot be accepted by the local infrastructures of the electric stations. On the other hand, when an accident happens with the local electric stations, the electricity supply to the HPP are switched off and the HPPs stop working.

Horticulture

One of the main similarities among the regions is that many respondents in Horticulture have mentioned about one fact that depending on the location of village the accessibility of water is tangibly different. The villages located close to the source of water (e.g. distribution point of the water user union) have better access of water than the villages which are located far from source of water.

Another common issue was reported to be inability of the farmers to measure the amount of water supplied to them. Because the gardens are not equipped with water meters, the farmers actually are not able to measure if they have supplied enough water as it is fixed by their contract or bills of payment for water.

The main difference among the regions is that in Ararat region many respondents have complained o the quality of water. Some respondents have mentioned that at the beginning of irrigation system during the first hours of receiving water, the water has dark color and very ugly smell. The locals use to call it "dark water".

The importance of water for different sectors of study.

Fish Farming

The Fish Farming is very sensitive to the quality of the water, in particular the temperature of the water and the oxygen content. Shortage of water may dramatically impact on the both characteristics of the water leading to tangible drop down of the productivity of a fish farm.

HPPs

HPP is very sensitive to the littering of ware with solid waste. Natural and anthropogenic solid waste accumulated in water results in industrial accidents in HPP leading to tangible expenditure for eliminating the accrued problem. On the other hand, the efficiency of the HPP depends a lot on the speed of flow of water. The HPP often collect water in reservoirs for further use in the turbines of the HPP. In case of decrease of accessibility of water, it takes from HPP longer time to collect water in the reservoirs because of which in the same time period the HPP generates significantly less electricity. Besides that when it takes longer time to collect water, this results in significant losses of water because of evaporation.

Horticulture

The findings of the sociological survey indicate that the most of the respondents consider that in land irrigations takes place significant losses of water, and 40-60% of water is lost on the way of source of water to the garden. These significant losses accrue because of poor condition and lack of relevant infrastructure. The water flows in open ground because of which the significant amount of water is absorb in the land and does not reach to the water users.

The sociological surveys indicate that in the case of shortage of water resources out of three observed sectors of Horticulture the most vulnerable are the old fruit gardens, as the potential of this sector to adapt to shortage of water resources is very limited. On the other hand, it is likely that in the case of shortage of water resources the farmers engaged in vegetable cultivation are more likely to suspend their further activity because of which the turnover of this sector may be decreased significantly.

The most draught resistant sector is grape growing, on the other hand the wine gardens start to bring profit in 2-3 years after establishment of the garden, while the fruit gardens start to bring profit in 5-6 years after establishment of the garden. Given this fact the water user associations

have clear scheme of priorities in supply of water, giving the most importance to Fruit Gardens, then the Wine Gardens and relatively less importance to Vegetable Gardens.

In scopes of the sociological survey was collected as well such information which enables to estimate the annual monetary value of products produced with 1 m^3 water for such sectors as Fish Farming, Viticulture, Fruit Gardening and Vegetable Gardening.

The conclusions on the estimations of "Annual monetary value of products produced with 1 m^3 water" is briefly presented in Table 1, and in details in Annex 2. The key findings of the sociological survey are summarized and presented in Table E and Table F of Annex 2.

Table 1. The estimation of the monetary value of products produced with 1 m^3 water/ AMD according to the sociological surveys.

	Average monetary value of product produced with 1 m^3 water/ AMD in Ararat region	Average monetary value of GDP produced with 1 m^3 water/ AMD in Vayots Dzor region
Mature vineyard /old than 5 years/ with drip irrigation	700-750	800-900
Mature vineyard /old than 5 years/ with standard irrigation	400-450	350-400
Mature fruit garden /old than 5 years/ with drip irrigation	600-650	600-650
Mature fruit garden /old than 5 years/ with standard irrigation	350-400	350-400
Vegetable cultivation with drip irrigation	550-600	600-650
Vegetable cultivation with standard irrigation	250-300	300-350
Fish Farming	20-30	30-60

3.3 Conclusions and next steps

The findings of the sociological survey may be used for development of activity plan aimed at increasing the efficiency of management of water resources and for conducting calculations on the economic value of water for different sectors of the study.

Potential contribution to the economic valuation of the value of water:

The findings of the sociological survey may be used for cross-checking the conclusions of the economic valuation of the value of water. In particular, for 4 out of 5 sectors of study (Fish Farming, Viticulture, Fruit Gardening and Vegetable Gardening) the sociological survey provides insights on such information as: a) the annual monetary value of products produced with use/consumption of 1 m^3 of water, b) dependency of the sector on the accessibility of water, c) potential of the sector to decrease the dependency on the accessibility of water.

Potential contribution to designing of activity plan aimed at mitigation of problems related to effective management of water resources.

The findings of the sociological survey include such information as actual and potential problems related to the quality and accessibility of water for different sectors and stakeholders. The RBMP may include a section on planning of actions for mitigation of existing key problems and prevention of potential problems identified by the respondents.

Potential contribution to designing of activity plan aimed at mitigation of conflicts of interests among different sectors.

The findings may be used as well for designing initiatives to reduce conflict of interests among different sectors and stakeholders. Especially, according to the findings of the survey, different sectors of agriculture have different vulnerability towards the accessibility of water and different potential to decrease the dependency on the accessibility of water. Based on this information the RBMP may include a section on planning actions to decrease the dependency of different sectors on accessibility of water.

4. Developing framework for valuing ecosystem services in the Ararat BMA

4.1 Methodology

Given that there is no widely accepted methodological approach to economic valuation of natural resources in Armenia, the available accurate and relevant database (consisting of three selected sectors and revenue and expenditure of 114 water users) is limited[1]. In this case, a methodology[2] adapted to the database available in Armenia was chosen, a SWOT analysis was carried out and the following preferred methodological approaches and indicators were proposed.

- The methodological approach for calculating the **Gross Production** indicator has been viewed as an economic measure of water value in the sectors of fish farming, Horticulture production, and Hydroelectricity production sector, since the analytical methodology for market prices isn't suitable for the data available in Armenia.
- In the case of Total **Economic** Value methodological approach[3], only the direct use value of water resources has been considered (benefits directly obtained from water users, economic sectors, and recreational water users), while the assessment of recreational water use and indirect use value has been excluded.
- **Comparative evaluation** has been regarded as an acceptable approach for summarizing conclusions.

In summary, this study examined the strengths, weaknesses, opportunities, and limitations associated with the use of Gross Production[4], Total Economic Valuation, and Comparative methodological approaches for the Economic Assessment of one cubic meter of water within the contexts of Hydropower plants, Fish Farming, and Horticulture production[5]. These methodological approaches aim to facilitate the economic valuation of water resources as a form of Natural Capital (for the consumption of one cubic meter of water) and to accurately represent their most probable monetary value in accordance with the study's objectives and goals.

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[1] Strategy for the creation of innovative financial mechanisms in the field of nature conservation.

[2] Hua Zheng *et al*. 2023. Gross Ecosystem Product (GEP): Quantifying nature for environmental and economic policy innovation.
Maes, J. *et al*. 2018. Mapping and Assessment of Ecosystems and Their Services: An Analytical Framework for Ecosystem Condition.

[3] Environmental damage and responsibility evaluation of economic value. Methodologies, structure, measurements, implementation.

[4] Ouyang, Z.Y. *et al*. 2020. Using Gross Ecosystem Product (GEP) to value nature in decision making. Proceedings of the National Academy of Sciences of the United States of America 117: 14593–14601.

[5] Adžemović M., *et al*. 2012. Methodology for economic evaluation of water management.

Table 2. SWOT Analysis of Methodological Approaches for the Economic Valuation of Water Resources (per cubic meter and in Three Economic Sectors.

	Strengths	Weaknesses
Methodological Approach to Calculating Gross Production Indicator	The methodology provides quantitative measures for assessing the value of direct use of water resources, helping to evaluate their worth. The Gross Production method allows for the assessment of various uses of water resources, such as Hydropower, Fish Farming, and Horticulture production, utilizing accessible databases with economic indicators. By quantifying economic outcomes, mathematical approaches can also be employed.	It requires extensive and precise data collection by sector, which can be time-consuming and difficult to access. The methodology for calculating Gross Production necessitates specialized and sector-specific knowledge, and a lack of this expertise can complicate the calculation of results. Economic evaluations can vary depending on each water user and the region (such as the Ararat and Vayots Dzor provinces), as well as the type of farming practiced by individual operators (intensive vs. extensive), making the application of the Gross Production methodology for one cubic meter of water more complex.
Comparative assessment analytical methodological approach	It has allowed for a direct comparison of the economic efficiency of different water uses (Hydropower, Fish Farming, Horticulture). It has helped identify the best uses of available water resources, contributing to optimization and an increase in overall productivity. As a result of benchmarking, it has provided a	It requires comprehensive data from various sectors, which aren't always available or comparable across systems. For instance, in Fish Farming, the regional gross production figures aren't officially published. It may not adequately account for dynamic changes over time, such as the intensive developments in sectors, the introduction of new market

	comparative framework for performance against other sectors or regions.	mechanisms (like agricultural insurance), or shifts in climate factors.
Methodological approach to assessing Total Economic Value	In these assessment calculations, the Total Economic Valuation method includes all direct revenues or direct use values derived from water resources, providing a comprehensive view of economic performance. It offers clear and straightforward financial indicators (like total revenue and turnover) that are easily understood by stakeholders and investors.	This approach mainly emphasizes financial indicators while overlooking non-market values from ecosystem services (meaning it excludes indirect use benefits, like those from biodiversity and ecosystem resilience). It requires meticulous and accurate data collection on revenues, which can be difficult and time-consuming, especially in resource-poor areas. Market volatility can lead to significant fluctuations in revenue, making it hard to maintain consistent assessments over time. There's a risk of overestimating real income if future market conditions or changes in demand aren't properly considered.
	Opportunities	**Threats**
Methodological Approach to Calculating Gross Production Indicator	Economic assessments can influence policymaking, leading to improved regulations and support for sustainable practices across various sectors. Digitizing data according to sector-specific and spatial alignment can enhance the accuracy and effectiveness of economic evaluations.	Climate change can impact both the quantity and quality of water, which might make existing economic assessments outdated or inaccurate. Different water tariffs set across sectors (like Hydropower, Horticulture, and Fish Farming) can lead to significant variations in the cost structures of Gross Production, potentially hindering

		cooperative management efforts. Due to market instability, fluctuations in market prices for Hydropower, Fish Farming, and Horticulture production tied to water quality and availability can cause drastic negative changes in Gross Production in these sectors. Conversely, increased investment in intense development in the sector could sharply boost gross production, but there are no indicators planned for these sudden changes.
Comparative assessment analytical methodological approach	This approach allows us to look at model schemes for inter-sectoral cooperation that could lead to integrated strategies for managing water resources, benefiting everyone involved, like in the case of secondary use of water resources.	The conflicting demands of different sectors on limited water resources can complicate comparative assessments and lead to conflict between stakeholders, for example regarding water resources as a primary factor of production versus an auxiliary factor of production.
Methodological approach to assessing Total Economic Value	Modern approaches to data digitization, collection, and analysis can enhance the accuracy and efficiency of Revenue assessments. Expanding new markets for fish and agricultural products produced through efficient methods can boost income flow and economic viability. The results can guide policymakers to create incentives	Climate change and water scarcity can reduce resource availability, leading to lower incomes and economic instability. Changes in water use and environmental protection regulations may affect revenue generation in these sectors. Economic downturns or changes in consumer preferences may affect market prices, leading to a possible reduction in revenues for the

	and frameworks that support optimal practices in water resource management and sustainable development.	sectors involved. And all these can immediately affect the overall Economic Value, without mentioning the real basis.

The consumption of water resources, along with the decrease of both qualitative and quantitative indicators, can negatively affect national macroeconomic indicators, in particular, the Gross National Product. The Gross Domestic Product (GDP) also does not take into account the consumption of water resources, which does not allow for a more accurate presentation of economic activity and social well-being. However, measures of Gross Product based on water use sectors can help identify issues between volumes of water used, environmental costs and economic benefits, as current measures often overlook this. The Gross Product methodological approach is used to economically evaluate cubic water resources by measuring the Total Value of output produced by selected sectors such as Hydropower, Fish Farming and Horticulture. This approach focuses on the value created by these sectors and overall economic productivity, emphasizing their role in the production of goods and services.[6]

The methodological approach for assessing the Economic Value (revenue) of cubic water resources focuses on estimating the total financial revenues from the direct use of water resources in specific sectors, particularly Hydropower, Fish Farming, and Horticulture[7]. This approach quantifies all the direct revenue flows related to water use, providing a comprehensive picture of economic benefits.

The comparative assessment method employs an analytical approach to evaluate the economic viability and efficiency of water resource usage across different sectors. This method proved especially useful when comparing the various revenues generated by different water users, such as the Total Value and Gross Product created in the Hydropower, Fish Farming, and Horticulture sectors from the volumes of surface water resources used by 114 water users in the Ararat Basin.

[6] Turner *et al*. 2004. Economic valuation of water resources in agriculture from the sectoral to a functional perspective of natural resource management.

[7] Rupert Q. G. 2023. The price and value of water: An economic review, Published online by Cambridge University Press.

4.2 Final Calculations

Due to the lack of reliable official published data on direct and indirect costs in the sectors involved in the research, such methodological approaches to the calculation of the Economic Evaluation were chosen, which are based on the following main indicators (which are confirmed by official publications).

- Resource **Use Fee and water Use Tariff** for 1 m³ of water (in AMD). This shows the water charge rate per cubic meter for each sub-sector.
  - The resource Use Fee set for Hydropower generation is 0.1 AMD[8].
  - For the Horticultural sector, the irrigation Tariff is set at 9.6 AMD (excluding VAT), and the resource Use Fee is 0 AMD[9].
  - In the Fish Farming sector, the resource Use Fee for surface water use is 0.975 AMD[10].

2. **The volume of water used by each subsector** and each water user **(m³/year)**: This shows the total annual water consumption by each subsector and 114 water users. These figures vary in the database of water use permits for each sector, and it is necessary to present a comparable unit, as it highlights the water dependence and use intensity of each segment. The annual volume of water used was calculated and converted from l/s and m³/year; a different approach was applied for the Horticulture sector, where the number of days allocated for irrigation is 210 days[11]. The application of the calculations is shown in Figures 3, 4, and 5.

***Calculation 1**:*
Calculation of the proportionality of the unit of measurement of the volume of water used = l/s X 0.001 x 18,144,000 (Horticulture sector) or 31,536,000 or cubic meters/s x31,536,000

[8] Nature use fee rate for each cubic meter of surface water used for hydropower purposes. Water use Fees in AMD. National Assembly of the Republic of Armenia.
[9] Tax Code, Articles 204.1 on resource use fees.
[10] Natural use fee in case of water use for fish farming. Water use Fees, AMD, Tax Code, Articles 204.1 and 214.2 on resource use fees.
[11] A typical calculation example is given by sector (Figure 3,4,5), Annex 3

3. **The Total Value (cost) for water use from resource use fees and water tariffs (AMD):** This represents the expenses incurred from water use fees. It reflects the value paid by each water user for their water use volume according to the financial contribution of the subsector to the water management system. At the same time, it helps to understand the financial burden of water use in each segment (as a main investment). The application of the calculations is shown in Figures 6, 7, and 8.

Calculation 2:
Total Value (cost) from water use fees = Annual water production X fees (excluding value added tax)[12]

4. Calculation of **the Total Value generated by the subsector (revenue) (AMD/year):** This represents the total economic value generated annually by each subsector. It pertains to the overall value of goods produced or sold. For the Hydropower sector, 53 water use permits were issued based on the Tariffs[13] set by the Public Service Regulatory Commission for energy-producing water users, as well as the average annual energy production capacities of Hydropower plants[14].

Calculation 3:
Total value generated by the subsector (revenue) (AMD/year) = (Rate set by the Public Service Commission for water users who generate energy) X (Average annual energy production capacities of Hydropower plants).[15]

In the Horticulture sector, this indicator is calculated based on the value of the Gross Product obtained in the sector. It can be calculated by summarizing the volumes of water use and the average weighted prices of the Gross Product across all individual sectors. The application of this approach is justified by the fact that the spatial boundaries of the Ararat basin do not coincide with the entire territory of the Ararat and Vayots Dzor regions. Furthermore, in the Horticulture sector, the Gross Product of Ararat and Vayots Dzor regions has not been calculated in terms of natural units because

[12] A typical calculation example is given by sector (Figure 6,7,8), Annex 3.

[13] The decision of the Public Services Regulatory Commission on the establishment of electricity sales from electricity supplied by electricity from the use of electricity to renewable energy resources in the territory of the Republic of Armenia, Tariff of hydroelectricity in AMD, expired on 30.06.2024, calculations were made on the basis of 2023 databases.

[14] Public Services Regulatory Commission of the Republic of Armenia (Small HPPs electricity) Annual useful delivery of electricity (million kWh), Volume of Water Used, for HPP, m^3/sec.

[15] A typical calculation example is given by sector Figure 9, Annex 3.

- According to 39 water users, there is a lack of data that would allow for an accurate assessment of the volumes of products produced by intensive and extensive farmers.
- The application of these two approaches excludes the appropriate application of land categories for agricultural lands.
- It is impossible to more accurately determine the direction of agricultural activities based on the water use permit obtained by the entity.

That's why the water use volumes of the 39 water users have been given a weighted average index (Figures 9, 10, 11), along with the Gross Product produced in the specified region for the ***Horticulture*** sector. The Gross Product in Horticulture indicates how effectively each sector converts water into valuable products. Gross Product serves as a basis for the official reports from the Statistical Committee[16], which include (as defined in the statistical methodological guidelines)[17]:

- The value of produced grains and leguminous crops, industrial crops, potatoes, vegetable crops, fruits and berries, grapes, fodder crops, agricultural seed materials, and perennials.
- The establishment and cultivation costs of perennial crops.
- The change in the value of unfinished Horticultural production (expenses for fall planting, frost protection, and other work done in the reporting year for the next year's harvest).

The total value generated by the Horticulture sector (revenue) (in currency/year) has been calculated by summing both regions (Figure 12).

5.The **Gross Product created by one cubic meter of water (kWh/m³, kg/m³, AMD)**: This measures the **Gross Product** of Hydropower, Fish Farming products, and Horticulture production produced using one cubic meter of water resources, expressed in both monetary and physical terms. Information about the **Gross Product** of the Fish Farming sector (in volume and monetary terms) was gathered from the activities of 22 economic entities that obtained water use permits for Fish Farming, which include individual entrepreneurs and legal entities engaged in fish hatchery operations, raising juvenile fish, and producing commercially viable fish (like carp and sturgeon)[18]. Here, the data was also limited, as the official figures are quite general. In other words,

[16] Statistical Service Bulletins - Gross product, AMD.
[17] Statistical indicators methodological explanations.
[18] List of Water Use Permits published by the Ministry of Environment, Volume of Water Used, for Fish Farming, l/sec.

there is no specific data regarding surface waters of the Ararat River basin. For Fish Farming sector study, data was also provided by the Ministry of Economy of the Republic of Armenia and the Statistical Committee. It's important to note that in the Ararat region, the Gross Product of fish products obtained from a reservoir with an average volume of 166 cubic meters is 10 kg, while in Vayots Dzor, it's 4 kg (in physical terms)[19]. A crucial consideration is that this figure does not consider the regular water flow in the reservoir, the fish production period (12 months)[20],[21] and that at least two fish species can be produced in the same reservoir within a year[22]. That's why the water use volumes have been assigned an average weighted indicator (Figure 8, which follows the same typical calculation), based on the consumer prices of commercial fish products (estimated using the Laspeyres method).[23]

Calculation 4:

Total value generated by Fish Farming enterprises (revenue) (AMD/year) = (Gross: Product of fish products in the calculated average reservoir of the Ararat region x production price of carp and sturgeon) / (average weighted indicator of water use volumes) (Figure 12)[24]

Calculation 5:

Gross Product per m³ of water = Total value created by the sector (revenue) (AMD/year) / Total volume of water used by water users in the sector (m³/year). *(Figure 13, 14, 15)*[25]

4.3 Key results, Monetary values

Based on the indicators selection and mathematical features of the methodological approaches I proposed above, the main results obtained from 114 water users in the fields of Hydropower Production (53), Fish Farming (22), and Horticulture (39) are presented in Table 3.

[19] Gross Product of agriculture, forestry and fisheries.

[20] The fisheries sector of the Republic of Armenia study.

[21] Mirzoyan *et al*. 2018. Groundwater use and efficiency in small- and medium-sized Fish Farming farms in Ararat Valley.

[22] Final Report on the Inventory of Groundwater Wells, Natural Springs and Fish Farms in the Ararat Valley.

[23] Calculation of the chain index of Lyspereis, in the Consumer Price Index according to the ASSEMBLY 2-5 digit classification under the code 01.1.3.1 "Fish - fresh or frozen" product price index in December 2023 compared to December 2016 The source, RA Central Bank, Consumer Price Index in January-December, 2016-2023. monthly reports.

[24] A typical calculation example is given by sector Figure 14.

[25] A typical calculation example is given by sector Figure 15,16,17.

Table 3. Results of the economic valuation of the ecosystem services (Hydropower, Fish Farming and Agriculture/Horticulture sectors) in the Ararat Basin Management Area (Ararat and Vayots Dzor regions), 2023.

Sub-sector	Fee for 1m^3 water, AMD	Total water used per sub sector, m^3/year	Total Value (Cost) from Water use Fees, AMD	Gross Product of water (AMD/m^3)	Total value (revenue) created by sub-sector, AMD/year
HPPs	0,1	15,942,961,728	1,594,296,173	0.348 AMD/m^3	5,554,344,853
Fish Farming	0,975	43,191,705	42,111,913	159 AMD/m^3	6,873,063,943
Agriculture/ Horticulture	9.6	197,376,419	1,894,813,625	469 AMD/m^3	92,641,421,040

When assessing the Economic Value of surface water used by water users who have received permission to produce Hydropower plants in the Ararat River basin, it was assumed that the pricing structure is different, because there are no market mechanisms for pricing electricity from hydroelectric power stations in Armenia (that is, a natural monopoly). The hydroelectric power sales market is classified as a natural monopoly, mainly due to high infrastructure costs and multiple suppliers. Although the process of liberalization of the electricity market started in February 2022 and entered the practical phase, new transactions have not yet taken place in the domestic market. In this context, hydroelectric plants sell electricity to distribution plants at government-regulated prices, known as the primary market. These distribution stations then resell the electricity to end consumers, such as households and businesses, at rates set by the Public Service Regulatory Commission[26].

The study uses a database of primary electricity sales prices and the capacities of produced (supplied) energy for analysis[27]. As a result, the total value of the sector has been calculated over

[26] The decision of the Public Services Regulatory Commission on the establishment of electricity sales from electricity supplied by electricity from the use of electricity to renewable energy resources in the territory of the Republic of Armenia. Tariff of Hydroelectricity in AMD, expired on 30.06.2024, calculations were made on the basis of 2023 databases.

[27] Public Services Regulatory Commission of the Republic of Armenia (Small HPP electricity), Annual useful delivery of electricity (million kWh), Volume of Water Used, for HPP, m^3/sec.

the year, showing that 53 water users[28] with permits to produce electricity generate a value of 5,554,334,853 AMD. Furthermore, this value in the secondary market could be even higher if we include the minimum profit norm. Starting from January 2024, only a fee for water use has been established in the Hydroelectricity production sector r, totaling 1,501,990,317 AMD. However, the energy production per cubic meter of water in the Hydroelectricity Production sector is 0.348 AMD/m^3.

Here, instead of market prices, the electricity sale tariffs have been used. The overall economic value of the sector (revenue) has been determined by the electricity sale tariffs and the amount of electricity produced, as the volume of water used by the plant is already included in the calculation of Gross Energy Product. The reason the volume of water used isn't counted in the sector's total value calculation is to avoid double counting. Additionally, the fees paid for water use in Hydroelectricity Production have been calculated at the rate of 0.1 AMD set by the 2024 decision; otherwise, the water use fees for Hydroelectricity Production wouldn't be calculated since in 2023 it was zero[29]. These calculations have been done to express the volume of environmental investments for comparative assessment, which should later be purposefully used by the community or state for the preservation of ecosystem services of the surface water resources in the Ararat River basin.

In the Ararat River basin, water users (22)[30] who received a permit for Fish Farming were evaluated according to the surface water they used, considering the current production prices[31] of the products included in the Gross Product and the established rates for water use fees (**0.975 AMD**)[32]. As a result, the total cost of the sector was calculated, as well as the cost of these fees, and the total cost received from water use in the sector is **42,111,913** AMD. During 2023, these 22 Fish Farming water users created a value of **6,873,063,943** AMD, and in the secondary and export markets, this value could be even higher if we consider the minimal profit margin.

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[28] List of Water Use Permits published by the Ministry of Environment, - Volume of Water Used, for HPP, m^3/sec.

[29] Natural use fee rate for each cubic meter of surface water used for hydropower purposes - Water use Fees in AMD. National Assembly of the Republic of Armenia.

[30] List of Water Use Permits published by the Ministry of Environment, Volume of Water Used, for Fish Farming, l/sec.

[31] Statistical Commit sv_12_23a_122 (armstat.am) Product price of Fish product, AMD, Statistical Commit Bulletins, - Gross Product, kg.

[32] Natural use fee in case of water use for fish farming. *Water use Fees*, AMD, Tax Code, Articles 204.1 and 214.2 on resource use fees.

In Agriculture, particularly in Horticultural Production, water is seen as a key natural resource for irrigation, and 39 water users have been involved in this research[33]. However, due to a lack of data on individual water users from the permits database, we could not calculate the average yield for specific water users. This means we also can't know exactly what kind of agricultural activities individual water users are engaged in or at what prices they're selling or exporting their products for. Instead, we're relying on officially published figures of Gross Production for each region (Ararat and Vayots Dzor regions)[34]. Therefore, average weighted values have been assigned to the Gross Production of each region and the volumes of water used by the water users.

The **Horticultural** Production sector continues to be crucial for maintaining food security, as it is slowly transitioning towards intensive agriculture with the help of government support. This segment has a zero cost for water use rights, but the water use service fee is **9.6 AMD** per cubic meter (excluding VAT)[35], and the Total Value from the water use (Cost) amounts to **1,894,813,625 AMD**. This is especially risky due to current expenses, which include the benefits of water conservation and intensive agriculture (thanks to new technological approaches). However, compared to Fish Farming, the overall value created is significantly higher at **92,641,421,040 AMD**.

4.4 Crosschecking and Validation of results

This comprehensive approach to ensuring accuracy and reliability in data analysis is essential, given its unprecedented applicability in the Economic Assessment of surface water flows in the Ararat Valley in Armenia across three sectors of economic activity. Due to limited and inaccessible data, periodic cross-checks have been conducted between the results of social surveys and the geospatial mapping data databases. As a result of these cross-checks, the number of water users (114) and the spatial assessment frameworks were aligned. Furthermore, the results of the social surveys led to the reevaluation of the outcomes for the 114 water users across the three economic

[33] List of Water Use Permits published by the Ministry of Environment, Volume of Water Used, for irrigation sector, l/sec.
[34] Statistical Service Bulletins, - Gross product, AMD.
[35] Public Services Regulatory Commission of the Republic of Armenia - Water use Fees, AMD.

activity sectors, which were initially assessed using an equal extrapolation methodological approach.

4.5 Conclusions and Next steps

Comparative assessment method is an analytical approach used to evaluate the viability of sectors such as Hydroelectricity Production sector, Fish Farming, and Horticulture by comparing the value generated by cubic meters of water with the respective Gross Value Added in the country. Specifically, the agricultural Gross Product in Armenia from January to December 2023 amounted to 948,040.1 million AMD[36]. During the same period, agricultural Horticultural production in the Ararat and Vayots Dzor regions amounted to AMD 120,200 million AMD, of which AMD 92,641.4 million AMD was generated through mechanical irrigation from surface waters of the Ararat River Basin. This means 77% of the gross agricultural output in the Ararat and Vayots Dzor regions is created from the surface waters of the Ararat River Basin. Due to the implementation of programs for intensive agricultural development, there was a 0.4% increase in 2023 compared to the same period in 2022; however, there was a 0.3% decrease in 2022 compared to the same period in 2021. Charges set for water use account for 1.62% of the Total Value, which can contribute to investments in the development of irrigation systems or intensive development programs.

The Gross Product of Fish Farming sector in January-December 2023, calculated at current prices, amounted to AMD 55,050 million[37]. According to the results of this study, AMD 6,873 million of this value was derived from the surface waters of the Ararat River Basin, accounting for 12.4% of the total. This research report presents a potential analysis of the economic valuation of water resources in three sectors—focusing on Hydroelectricity Production, Fish Farming, and Horticulture. The assessment results emphasize the importance of establishing a structural framework for managing the surface water resources of the Ararat River Basin, highlighting key outcomes and monetary values that reflect the true economic value of water used in these sectors.

[36] Gross Product of agriculture, forestry and fisheries, 2023 January – December, p 22.
[37] Gross Product of agriculture, forestry and fisheries, 2023 January – December, p 23.

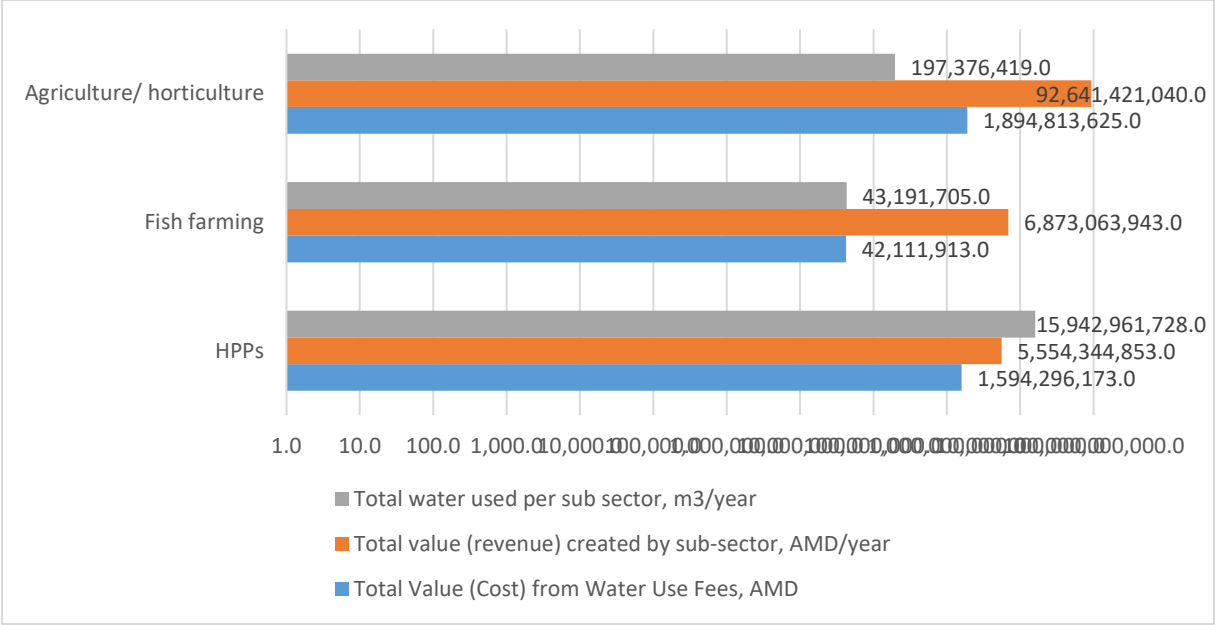


Figure 2. Regarding the total volume of water used by each sector, the corresponding fees incurred and the economic viability of the sector.

The analysis indicates that the overall water use and the corresponding fees provide essential insights into the economic viability of each sector. For instance, the Hydroelectricity Production sector annually uses approximately 15,942,961,728 m³ of water, generating around 1,594,296,173 AMD in water use fees at a rate of 0.348 AMD/m³ in Gross Production value, resulting in a Total Value (revenue) of 5,554,344,853 AMD. In Fish Farming, with a water fee of 0.975 AMD/m³ and a Total Use of 43,191,705 m³, the Total Value of water use fees amounts to 42,111,913 AMD, corresponding to a Gross Product Value of 159 AMD/m³ and Total Value (revenue) of 6,873,063,943 AMD. Meanwhile, the Horticulture sector shows significant results, with a water use of 197,376,419 m³ at a rate of 9.6 AMD/m³, resulting in 1,894,813,625 AMD in water Use Fees, a Gross Production Value of 469 AMD/m³, and Total Value (revenue) of 92,641,421,040 AMD.

These results can be useful in developing strategic programs for regional water resource management, particularly those related to the revision of water pricing structures and rates, as they reflect the economic value of water in Horticulture, Fish Farming, and Hydroelectricity Production

sector. Based on the monetary valuation of the water resources assessed across the three sectors of economic activity, it is also possible to:

- **Develop** a digital database of water resource data where transparency and accountability of water users' economic behaviors can be ensured. This database would allow water users to exchange the volumes of water resources they have used, saved, or deemed suitable for secondary use.
- **Develop** a strategic management plan guided by the principles of a green and circular economy, aiming to reduce water use quantitatively and maximize economic returns through secondary use. For example, integrating aquaponics in Fish Farming to promote circular water use.
- **Develop** a water pricing structure that increases rates associated with higher consumption levels, encouraging larger volume consumers to reduce and save both quantitative and qualitative water metrics for future efficient use or resale among Hydropower producers.
- **Develop** inter-sectoral collaboration schemes, such as between crop producers and Hydropower organizations, to reinvest increased charges in sustainable practices, thereby enhancing the environmental and economic viability of both sectors.

Additionally, it is important to note that the methodological approaches to the economic assessment of surface waters in the Ararat Basin can serve as a model for the economic assessments and policy decisions of other water basins, reinforcing water conservation efforts and improving overall resource management strategies to ensure water remains a natural asset for future generations.

Annex 1. Estimations for selection of the target agricultural value chains

Table A. Estimation of the monetary value of each of the sectors for Armenia.

	Share of each sector in the gross agricultural output in Armenia in[38] %	Estimated monetary value of each of the sectors /bln AMD[39]
TOTAL GROSS AGRICULTURAL OUTPUT in 2022	100%	1021.7
Grains and legumes	2.6%	26.5642
Potatoes	6.3%	64.3671
Vegetable	14.4%	147.1248
Melons	1.6%	16.3472
Fruit	11.0%	112.387
Grape	4.3%	43.9331

[38] «Հայաստանը թվերով 2022, բաժին՝ «գյուղատնտեսություն»»/ Armenia in figures 2022, section: "agriculture".

[39] Calculation of the author, besides the indicator: "Gross agricultural output: 1021.7 bln AMD", which is given in the same publication above.

Table B. Estimation of the weight of the gross output of each sector in monetary value in the gross agricultural output in monetary value for Ararat region.

	1	2	3	4
	See Table A	Calculation of the author based on Armstat info[40]	"1" x "2"	3 x 103.6125
	Estimated monetary value of Gross Agricultural Product by sectors in Armenia in bln AMD	Share of agricultural output of the region in gross agricultural output of Armenia	Estimated monetary value of Gross Agricultural Product by sectors in Ararat/ in bln AMD	Share of gross output in monetary value of each sector in the gross agricultural output in monetary value in Ararat
Grains and legumes	26.5642	3.0%	0.79791014	0.77%
Potatoes	64.3671	3.9%	2.53230893	2.44%
Vegetable	147.1248	30.8%	45.254765	43.68%
Melons	16.3472	29.0%	4.7394649	4.57%
Fruit	112.387	28.7%	32.2156357	31.09%
Grape	43.9331	41.1%	18.0724201	17.44%
Total	410.7234		103.6125	

[40] Armstat reports on "SOWN AREAS, AVERAGE YIELD CAPACITY AND GROSS HARVEST"

Table C. Estimation of the weight of the gross output of each sector in monetary value in gross agricultural output in monetary value for Vayaots Dzor region.

	1	2	3	4
	See Table A	Calculation of the author based on Armstat info[41]	"1" x "2"	"3" x 4.0626
	Estimated monetary value of gross agricultural product by sectors in Armenia in bln AMD	Share of agricultural output of the region in gross agricultural output of Armenia	Estimated monetary value of Gross Agricultural Product by sectors in Vayots dzor in bln AMD	Share of gross output in monetary value of each sector in the gross agricultural output in monetary value in Vayots dzor
Grains and legumes	26.5642	0.7%	0.18672781	4.60%
Potatoes	64.3671	0.3%	0.19373762	4.77%
Vegetable	147.1248	0.5%	0.79455168	19.56%
Melons	16.3472	0.3%	0.04484321	1.10%
Fruit	112.387	1.4%	1.57591987	38.79%
Grape	43.9331	2.9%	1.26688828	31.18%
Total	410.7234		4.06266846	

[41] Armstat reports on "SOWN AREAS, AVERAGE YIELD CAPACITY AND GROSS HARVEST"

Table D. Summary of rating the sectors of agriculture.

(calculated by the author based on Armstat reports) [42]

		Grains and legumes	Potato	Vegetable crops	Melon crops	Fruit and berries	Grapes
Total sown area/ ha	Ararat	2,246.0	489.0	4,080.0	1,006.0	8,892.0	4,722.0
	Vayots dzor	1,030.0	86.0	218.0	16.0	2,561.0	1,205.0
Share of cultivated land of each sector in total agricultural cultivated land in region	Ararat	10.5%	2.3%	19.0%	4.7%	41.5%	22.0%
	Vayots dzor	20.1%	1.7%	4.3%	0.3%	50.1%	23.6%
Volumes of agricultural output in cents	Ararat	87,287.0	143,413.0	1,868,624.0	338,207.0	1,035,307.0	877,952.0
	Vayots dzor	20,427.0	10,972.0	32,808.0	3,200.0	50,645.0	61,545.0
The share of agricultural output of region in total agricultural output of Armenia	Ararat	3.0%	3.9%	30.8%	29.0%	28.7%	41.1%
	Vayots dzor	0.7%	0.3%	0.5%	0.3%	1.4%	2.9%
Gross output in monetary value/ bln AMD (մլրդ դր)	Ararat	1.7	5.0	45.1	3.30	31.6	13.40
	Vayots dzor	0.30	0.20	0.70	0.06	1.90	0.8
Share of the gross output of each sector in monetary value in gross agricultural output in monetary value for region	Ararat	1.7%	5.0%	45.0%	3.30%	31.6%	13.4%
	Vayots dzor	7.6%	5.1%	17.7%	1.5%	48.0%	20.2%
Created gross output per ha, 1000 AMD	Ararat	757	10,225	11,054	3,280	3,554	2,838

[42] Armstat reports on “SOWN AREAS, AVERAGE YIELD CAPACITY AND GROSS HARVEST”

	Vayots dzor	291	2,326	3,211	3,750	742	664

Annex 2. Findings of the sociological survey

Table E. The main similarities and differences among the region.

	Ararat	Vayots dzor
Significant water losses accrue because of old and damaged irrigation system of the community	Yes	Yes
Significant water losses accrue because of absence of water reservoirs and dumbs	Yes	Yes
Significant water losses accrue because of absence of modern irrigation and water accumulation technologies in agriculture	Yes	Yes
Fish farms are the main subject of complains of the respondents	Yes	No
HPP are the main subject of complains of the respondents	No	Yes
The irrigation water is littered with solid waste	Yes	No
The irrigation water is littered with wastewater coming from houses and agricultural farms	Yes	No
The accessibility of potable water is limited	Yes	No
The respondents are concerned with the quality and quantity of water in near future	Yes	No

Summary of the key findings of the sociological survey

Table F1. Estimation of the "value of water" in Horticulture.

	1	2	3	4	5	6	7	8
	Survey data	Survey data	Survey data	"2"x"3"x1000	"4"/"1"	Survey data	("4"-"4"x"6")/ ("1"-"1"x20%)	Survey data
Vayots Dzor	Water consumption per ha	Harvest from 1 ha	Average bulk price for 1 kg of product	Monetary value of harvest from 1 ha	Average monetary value produced with 1 m^3 water	Potential decrease of harvest in the case of water shortage by 20%	Marginal monetary value produced with 1 m^3 water	potential to reduce water consumption
UNIT	m^3	Tones	AMD	AMD	AMD	%	AMD	%
Mature vineyard with drip irrigation	4,500	16	250	4,000,000	890	40%	666.67	20%
Mature vineyard with standard irrigation	11,000	16	250	4,000,000	364	40%	272.73	60%
Mature fruit garden with drip irrigation	6,000	12	300	3,600,000	600	50%	375.00	20%
Mature fruit garden with standard irrigation	10,000	12	300	3,600,000	360	50%	225.00	50%
Vegetable cultivation with drip irrigation	7,000	60	70	4,200,000	600	60%	300.00	10%
Vegetable cultivation with standard irrigation	14,000	60	70	4,200,000	300	60%	150.00	40%

	1	2	3	4	5	6	7	8

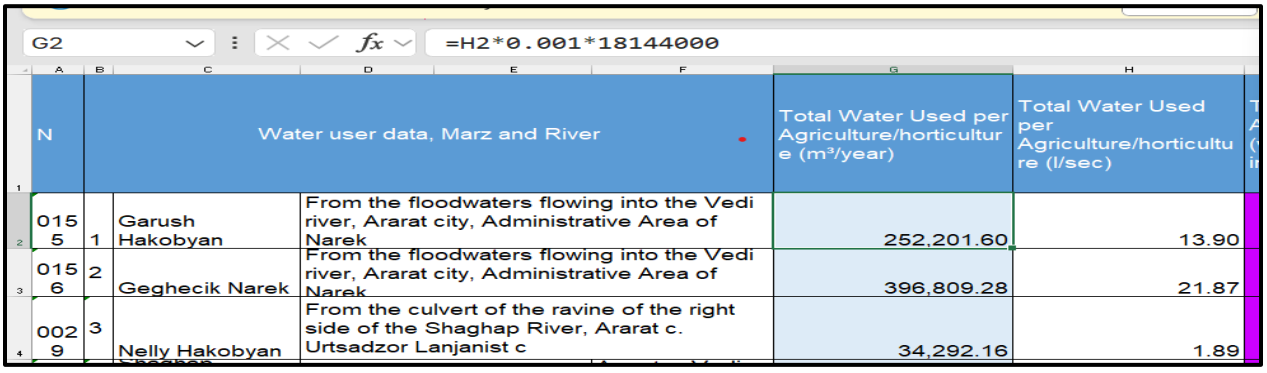
	Survey data	Survey data	Survey data	"2"x"3"x1000	"4"/"1"	Survey data	("4"-"4"x"6")/ ("1"-"1"x20%)	Survey data
Ararat	Water consumption per ha	Harvest from 1 ha	Average bulk price for 1 kg of product	Monetary value of harvest from 1 ha	Average monetary value produced with 1 m^3 water	Potential decrease of harvest in the case of water shortage by 20%	Marginal monetary value produced with 1 m^3 water	potential to reduce water consumption
UNIT	m^3	Tones	AMD	AMD	AMD	%	AMD	%
Mature vineyard with drip irrigation	5,000	25	140	3,500,000	700	40%	525.00	20%
Mature vineyard with standard irrigation	8,000	25	140	3,500,000	438	40%	328.13	60%
Mature fruit garden with drip irrigation	6,000	15	250	3,750,000	625	50%	390.63	20%
Mature fruit garden with standard irrigation	10,000	15	250	3,750,000	375	50%	234.38	50%
Vegetable cultivation with drip irrigation	7,000	50	80	4,000,000	571	60%	285.71	10%
Vegetable cultivation with standard irrigation	14,000	50	80	4,000,000	286	60%	142.86	40%

Table F2. Estimation of the "value of water" in fish breeding.

1	2	3	4	5	6	7	8	9
Survey data	Survey data	"1"/1000 x 3600x24x365	"2" / "3"	Survey data	"4" x "5"	Survey data		Survey data
Water use permit l/second	Annual amount of fish produced with 1 l/second water use permit	Annual use of water 1 l/second water use permit	Annual amount of fish produced with 1 m^3 of water	Average price	Monetary value of product produced with 1 m^3 of water	Potential decrease of harvest in the case of water shortage by 20%	Marginal monetary value produced with 1 m^3 water	Potential to reduce water consumption
l/second	Kg	m^3	kg	AMD	AMD	%	("3" – "3"x20%)	%
1	700	31,536	0.022	1000	22	50		NA

Annex 3 Calculations

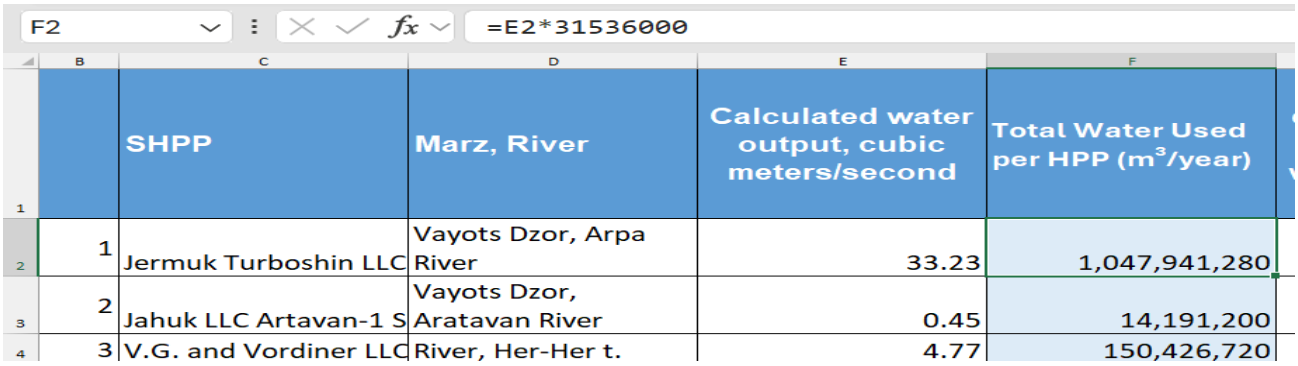
Figure 3. Horticulture sector, calculation of the proportionality of the unit of measurement of the volume of water used (blue column).



G2 | =H2*0.001*18144000

	N		Water user data, Marz and River		Total Water Used per Agriculture/horticulture (m³/year)	Total Water Used per Agriculture/horticulture (l/sec)
2	0155	1	Garush Hakobyan	From the floodwaters flowing into the Vedi river, Ararat city, Administrative Area of Narek	252,201.60	13.90
3	0156	2	Geghecik Narek	From the floodwaters flowing into the Vedi river, Ararat city, Administrative Area of Narek	396,809.28	21.87
4	0029	3	Nelly Hakobyan	From the culvert of the ravine of the right side of the Shaghap River, Ararat c. Urtsadzor Lanjanist c	34,292.16	1.89

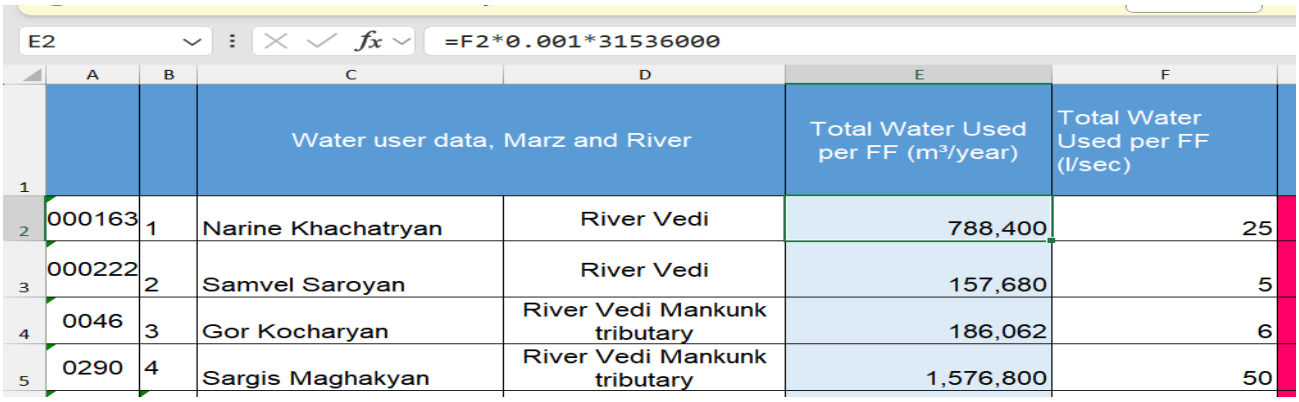
Figure 4. Hydroelectricity production sector, calculation of the proportionality of the unit of measurement of the volume of water used (blue column).



F2 | =E2*31536000

		SHPP	Marz, River	Calculated water output, cubic meters/second	Total Water Used per HPP (m³/year)
2	1	Jermuk Turboshin LLC	Vayots Dzor, Arpa River	33.23	1,047,941,280
3	2	Jahuk LLC Artavan-1 S	Vayots Dzor, Aratavan River	0.45	14,191,200
4	3	V.G. and Vordiner LLC	River, Her-Her t.	4.77	150,426,720

Figure 5. Fish Farming sector, calculation of the proportionality of the unit of measurement of the volume of water used (blue column).



E2 | =F2*0.001*31536000

			Water user data, Marz and River		Total Water Used per FF (m³/year)	Total Water Used per FF (l/sec)
2	000163	1	Narine Khachatryan	River Vedi	788,400	25
3	000222	2	Samvel Saroyan	River Vedi	157,680	5
4	0046	3	Gor Kocharyan	River Vedi Mankunk tributary	186,062	6
5	0290	4	Sargis Maghakyan	River Vedi Mankunk tributary	1,576,800	50

Figure 6. Horticulture sector, calculation of Total Value (cost) from Use Fee for water use (red column).

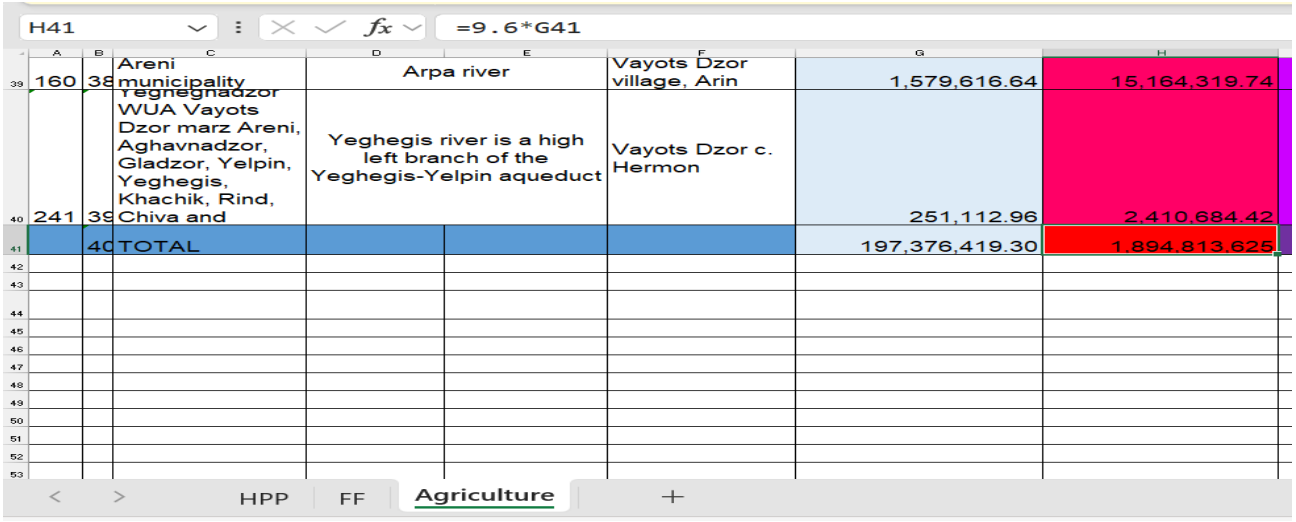


Figure 7. Fish Farming sector, calculation of Total Value (cost) from Use Fee for water use (red column).

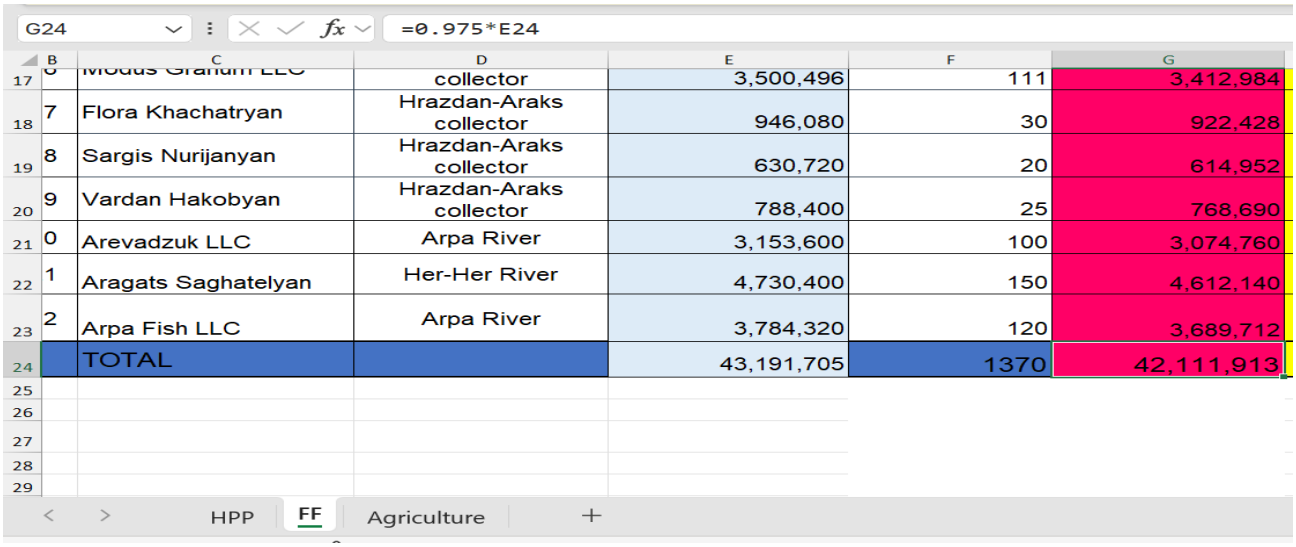


Figure 8. Hydroelectricity production sector, calculation of Total Value (cost) from Use Fee for water use (red column)

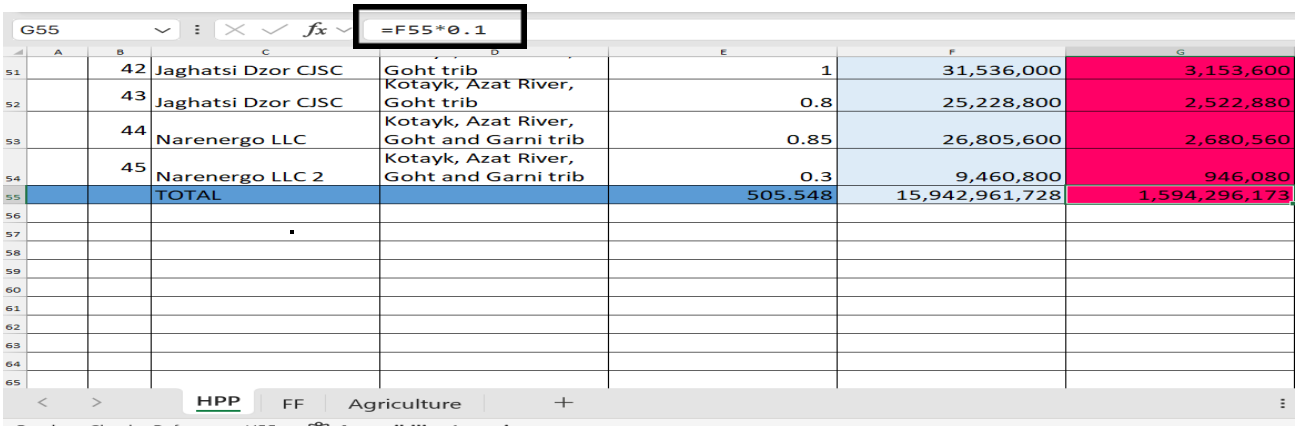
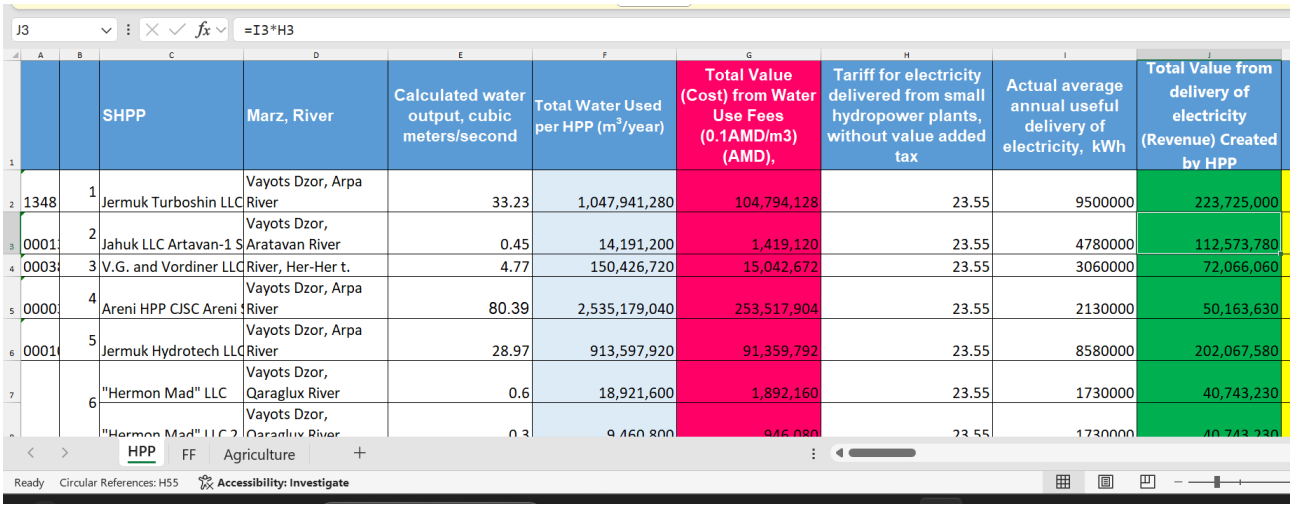


Figure 9. Calculation of the total value (revenue) generated by the Hydroelectricity Production sector (AMD/year) (green column).



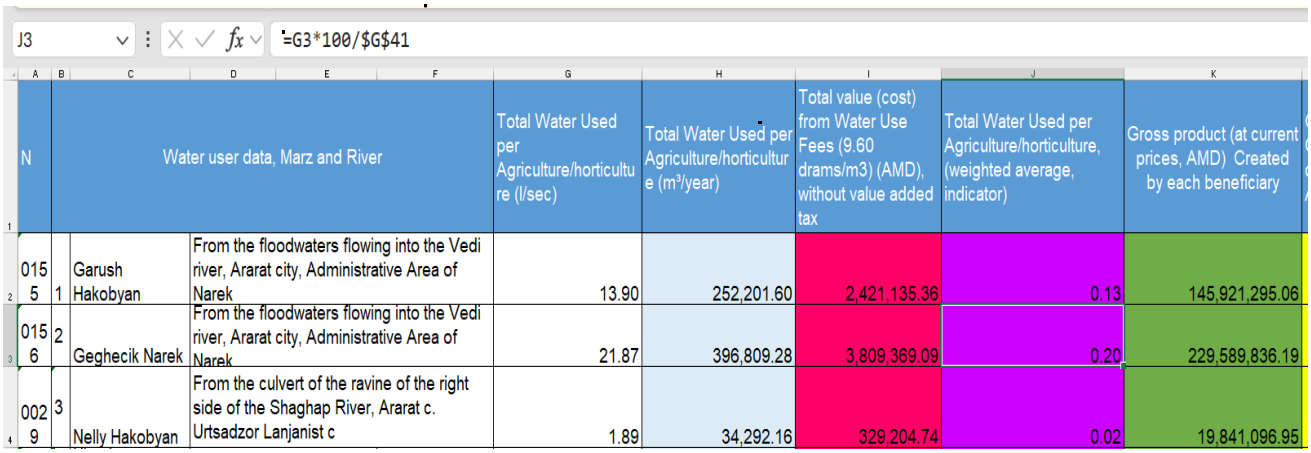
J3 =I3*H3

		SHPP	Marz, River	Calculated water output, cubic meters/second	Total Water Used per HPP (m^3/year)	Total Value (Cost) from Water Use Fees (0.1AMD/m3) (AMD),	Tariff for electricity delivered from small hydropower plants, without value added tax	Actual average annual useful delivery of electricity, kWh	Total Value from delivery of electricity (Revenue) Created by HPP
1348	1	Jermuk Turboshin LLC	Vayots Dzor, Arpa River	33.23	1,047,941,280	104,794,128	23.55	9500000	223,725,000
0001	2	Jahuk LLC Artavan-1 S	Vayots Dzor, Aratavan River	0.45	14,191,200	1,419,120	23.55	4780000	112,573,780
0003	3	V.G. and Vordiner LLC	River, Her-Her t.	4.77	150,426,720	15,042,672	23.55	3060000	72,066,060
0000	4	Areni HPP CJSC Areni	Vayots Dzor, Arpa River	80.39	2,535,179,040	253,517,904	23.55	2130000	50,163,630
0001	5	Jermuk Hydrotech LLC	Vayots Dzor, Arpa River	28.97	913,597,920	91,359,792	23.55	8580000	202,067,580
	6	"Hermon Mad" LLC	Vayots Dzor, Qaraglux River	0.6	18,921,600	1,892,160	23.55	1730000	40,743,230
		"Hermon Mad" LLC 2	Vayots Dzor, Qaraglux River	0.3	9,460,800	946,080	23.55	1730000	40,743,230

HPP FF Agriculture

Ready Circular References: H55 Accessibility: Investigate

Figure 10. The volume of water use was given a weighted average index determined by the Horticulture sector production in the region (Horticulture sector). (purple column).



J3 =G3*100/G41

N		Water user data, Marz and River		Total Water Used per Agriculture/horticulture (l/sec)	Total Water Used per Agriculture/horticulture (m^3/year)	Total value (cost) from Water Use Fees (9.60 drams/m3) (AMD), without value added tax	Total Water Used per Agriculture/horticulture, (weighted average, indicator)	Gross product (at current prices, AMD) Created by each beneficiary
0155	1	Garush Hakobyan	From the floodwaters flowing into the Vedi river, Ararat city, Administrative Area of Narek	13.90	252,201.60	2,421,135.36	0.13	145,921,295.06
0156	2	Geghecik Narek	From the floodwaters flowing into the Vedi river, Ararat city, Administrative Area of Narek	21.87	396,809.28	3,809,369.09	0.20	229,589,836.19
0029	3	Nelly Hakobyan	From the culvert of the ravine of the right side of the Shaghap River, Ararat c. Urtsadzor Lanjanist c	1.89	34,292.16	329,204.74	0.02	19,841,096.95

Figure 11. Based on the Total Value (revenue) generated by the Horticulture sector (AMD/year), Ararat region GP (114,200 million) [43] (green column).

[43] Statistical Service Bulletins, - ***Gross Product, AMD*** [PX-Web - Select variable and values (armstat.am)]

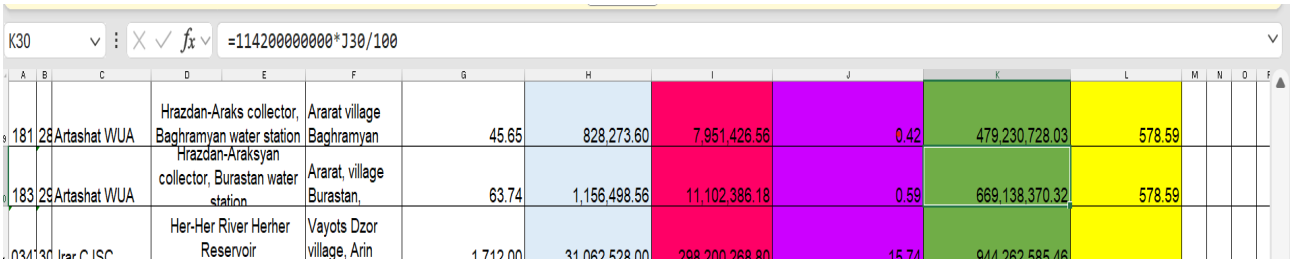


Figure 12. Based on the Total Value (revenue) generated by the Horticulture sector (AMD/year), Vayots Dzor region GP (6 million [44]) (green column).

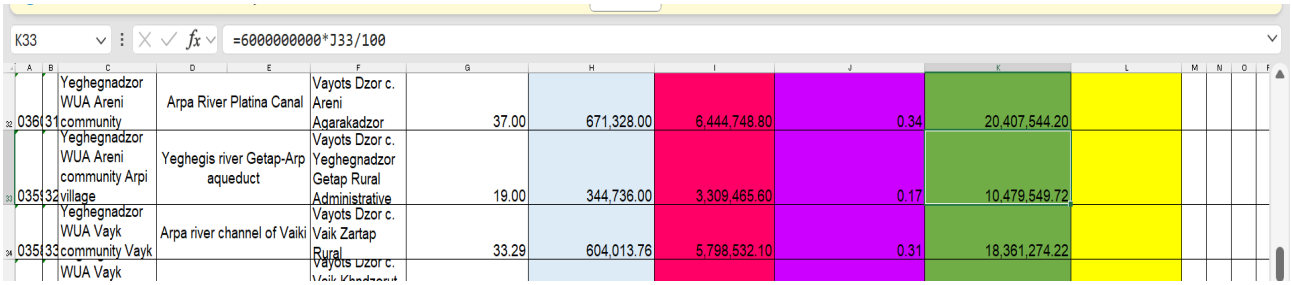


Figure 13. Total Value generated by the Horticulture sector (green column).

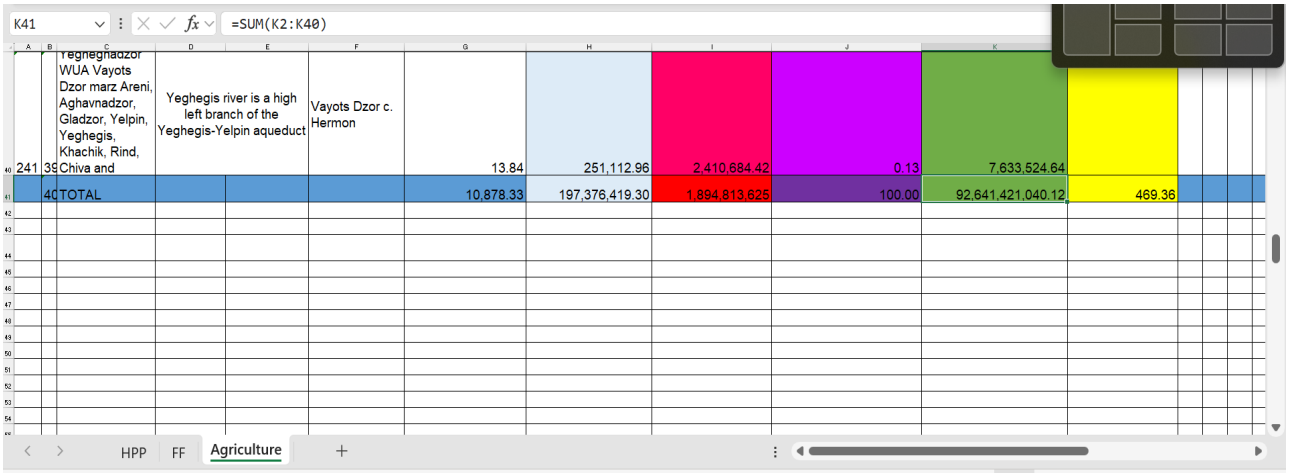


Figure 14. Calculation of the Total Value (revenue) generated by Fish Farming (AMD/year) (green column).

[44] Statistical Service Bulletins - ***Gross Product, AMD*** [PX-Web - Select variable and values (armstat.am)]

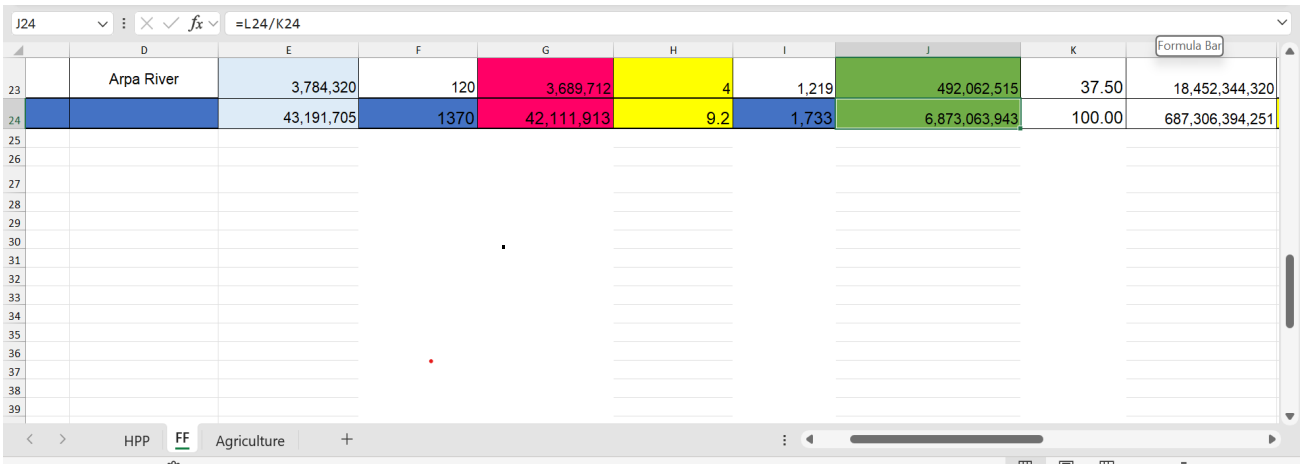


Figure 15. Calculation of the Gross Product of the Horticulture sector per m³ of water, calculation (yellow column).

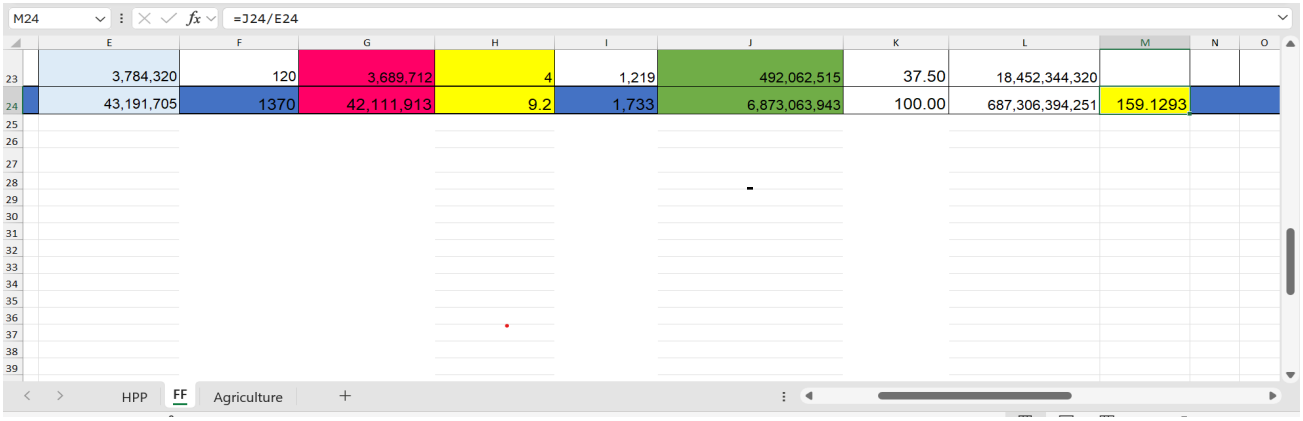


Figure 16. Calculation of the Gross Product of the Hydroelectricity production sector from one m³ of water, (yellow column).

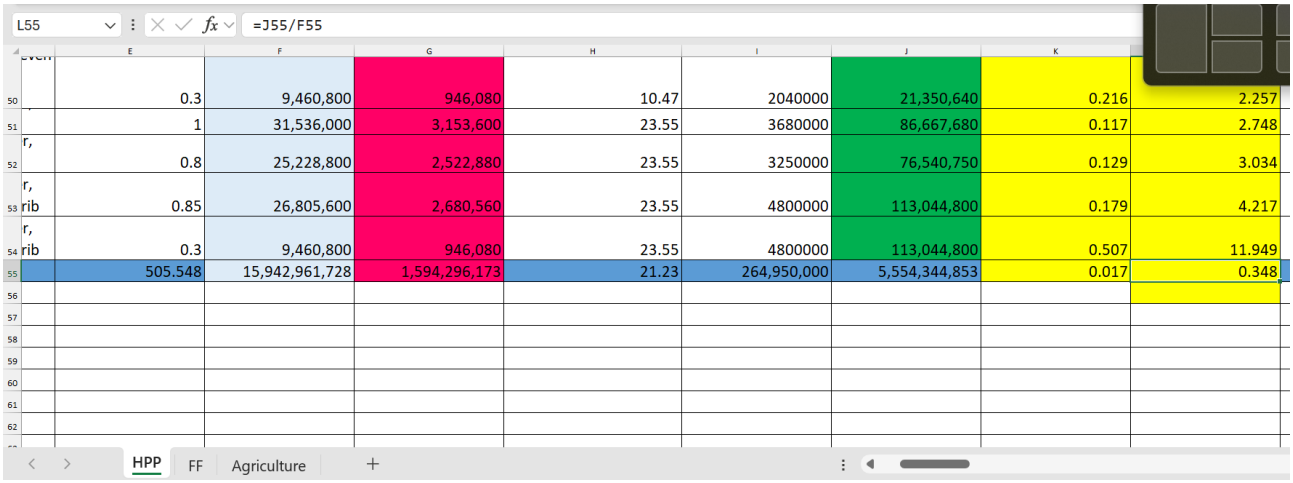


Figure 17. Calculation of the Gross Product of the Fish Farming sector from one m³ of water, (yellow column).