DOCTORAL DISSERTATION

Károly Kovács

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Károly Kovács:

REPLACEMENT NEEDS OF WATER UTILITY INFRASTRUCTURE
SOCIAL RESPONSIBILITY – NEEDS FOR SOLIDARITY

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Abbreviations, definitions

AWWA	American Water Works Association
VAT	Value Added Tax
CBA	Cost Benefit Analysis
BME	Budapest University of Technology and Economics
DCC	Dynamic Cost Comparison
ÉCS0	Depreciation based on the value upon capitalisation (original value)
ÉCS1	Depreciation based on full replacement value
ÉCS2	Depreciation based on depreciated replacement value
EU	European Union
EEA	European Environmental Agency
EurEau	European Federation of National Associations of Water Services
EWA	European Water Association
FAO	Food and Agriculture Organization of the United Nations
Willingness to Pay	Willingness of the consumer to pay for the services used, based on their value judgement
Affordability	Threshold established by administrative organs to indicate consumers’ presumed willingness and ability to pay
GFT	Rolling Development Plan
HWP	Hungarian Water Partnership
IWA	International Water Association
KÉM	Outlier Indicator
KvVM	Ministry of the Environment and Water Management

KvVM FI	KvVM Development Directorate
KSH	Central Statistical Office
MASZESZ – HWA	Hungarian Water Association
MAVÍZ	Hungarian Water Utility Association
MDG	Millennium Development Goals
MEKH - HEA	Hungarian Energy and Public Utility Regulatory Authority
MMK	Hungarian Chamber of Engineers
MTA	Hungarian Academy of Sciences
OECD	Organisation for Economic Co-operation and Development
OPÉ	Total Replacement Value
OPK	Aggregate replacement costs during lifecycle studied
OIPK	Aggregate drinking water replacement costs during lifecycle studied
OSZVPK	Aggregate wastewater replacement costs during lifecycle studied
OVÉ	Total asset value
SDG	Sustainable Development Goals
SZVPK	Wastewater utility replacement cost
Availability fee	Basic fee payable by the consumer regardless of the volume consumed
TIKA - MIAD	Multipurpose Infrastructure Assessment Database (software)
TKM	Full Cost Recovery
UNDS	United Nations Development System
Water tariff	Consumer tariff proportionate to the volume of water consumed (m^3)
VKI - WDF	Water Framework Directive
VKJ	Water resource fee
VKSZTV	Act CCIX of 2011 on water utility services
VPK	Water Utility Replacement Cost
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WOAH	World Organisation for Animal Health
WWC	World Water Council

Consistency index:	Index figure relating to the technical condition of the water utility object, showing the obsolescence of the given asset;
Replacement cost:	Total, exclusive of VAT, of costs that can cost-effectively cover the replacement of the water utility object at the time of the valuation and that can be defined by: *a) the cost of reproduction*, the cost of procuring or producing the asset identical to the original, or *b) the replacement cost*, the cost of procuring or producing the asset technically equivalent to the original;
Expected lifetime*:*	Lifetime of fixed assets determined at the time of the valuation, expected from a technical point of view;
Water utility object:	All identifiable water utility assets, the replacement cost of which can be substantiated through a technical cost calculation and the exact technical contents of which can be

	determined and one that meets the following criteria, at least: *a)* its spatial location can be determined, *b)* a lifetime figure can be attributed to the given asset at least by building, machinery, fixture, control technology, energy supply *c)* it represents a homogeneous unit in terms of its technical parameters determining its replacement costs;
Water utility-object-group:	Aggregate of technically interconnected water utility objects with a specific technological function;
Water utility asset inventory:	Object-level records of water utility systems or of their components, structured by sector and by water utility object group, suitable for assigning water utility objects to asset groups as defined in the accounting act.
Solidarity	Active involvement, in which the individual mobilises his resources in the interest of a collective goal, (Hechter, 1987), thereby strengthening social integration, unity and stability (Durkheim, 2001)
Social solidarity	Solidarity based on the recognition of long-term interests, as a result of which equalising-complementing actions take place, which handle differences between diverse groups.(Monostori, 2007)
Vertical solidarity	Sharing among generations of the cost of the development, maintenance and replacement needs of long-lasting infrastructure
Horizontal solidarity	Contribution to costs among those in small and large settlements, equalizing the often ten-fold cost difference in per capita/household water utility development, maintenance, replacement and operation among settlements of different sizes
Lorenz-curve	Shows cumulative relative values as a function of cumulative relative frequencies. In the study, the cumulative values of the actual annual replacement costs of settlements and settlement groups by size and the linearly growing average (evenly distributed) values of replacement costs for the period studied are shown in a coordinate system, similar to the approach used by the Lorenz-curve.
Cluster analysis	Splitting of elements of a set of data (in this case settlements) into various groups based on values established within a certain system of criteria (water utility infrastructure replacement and maintenance costs, financial situation of inhabitants, attitude towards solidarity, etc.)

1. Introduction

1.1 Personal involvement, motivation

As the leader of domestic and international non-profit interest representation organisations, as well as business entities working for the sustainability and development of water management, more specifically urban water management (HWA, EWA, ASEM WATER, HWP, EIP WATER, EU PLARFORM ON SUSTAINABLE FINANCE…), I am a committed advocate of enforcing the polluter pays principle, as well as the related cost recovery principle, as set forth in the WFD (European Parliament and the Council, 2000). As the advisor of international development banks, I conducted talks and negotiations about the (non)-fulfilment of these requirements at countless professional, policy and non-governmental fora, as well as events, conferences, meetings and discussions of various countries and continents the world over. It was in the course of planning and implementing of and preparing and evaluating feasibility studies for hundreds of water utility infrastructure development projects, as well as through the evaluation of the utility assets and coordinating the asset management activities of more than a thousand communities that I was confronted with the failure to recover both capital and replacement costs of infrastructure. The enforcement of the consumer/polluter pays principle and of the full cost-recovery principle is rendered impossible by the mention of the presumed or real affordability limit or willingness to pay, thereby making rational and transparent individual, as well as society-level decision-making relating to developments and maintenance impossible.

In summary, experience has shown that **urban water utility infrastructure is the most expensive among all types of infrastructure and the recovery in investment terms, of the water utility infrastructure development relying on bank financing alone, is the least probable.**

It is the most expensive, since, as is pointed out in UNEP (2013) *City-Level Decoupling: Urban resource flows and the governance of infrastructure transitions*. (Swilling *et al.*, 2013a), *"over the next 25 years for all the cities of the world, it estimates that a total of US$ 41 trillion is required to refurbish the old (in mainly developed country cities) and build new (mainly in the developing country cities) ... Over 50 per cent (US$ 22.6 trillion) would be required for water systems".* The recovery of bank financing alone is not to be expected, as in the Central Eastern European Region (which belongs to the wealthier part of the world), water utility developments funded predominantly through non-refundable subsidies from cohesion funds, not even the capital costs corresponding to an interest-free financing over a 50-year period (2%

depreciation annually) are reflected in the tariffs. The primary reason for this is the current interpretation of affordability and willingness to pay that caps the cost of water and wastewater services at 3% of household income. This does not allow even for the maintenance/replacement costs of the facilities built.

The fact that access to and sustainable management of water and sanitation (UNO Assembly, 2015), as set forth in the Sustainable Development Goals (SDG) of the UN, adopted in 2015, play a key role, demonstrates the importance of the issue. The principal topic and objective of the Budapest Water Summit organised this year for the third time, was **preventing global water crises**.

Regrettably, the environmental sustainability goals (MDG 7), and more specifically, the water objectives, identified at the turn of the millennium, have either not been met at all or have been met only partially (United Nations Economic Commission for Africa, 2015):

"Water scarcity is present on all continents hindering the sustainability of both natural resources and of economic and social development." (Inter-Agency and Expert Group on MDG Indicators, 2015) The final report of the MDG highlights an additional disparity dependent upon the size of the urban area: "*In urban settings four out of five, by comparison, in rural areas only one out of three people have access to pipelined water supply. Those living in rural areas and the poor and those in marginalised groups of society are less likely to have access to adequate drinking water and sanitation services and to benefit from pipelined water supply. Gradual elimination of disparities in access to services and in the standard of services should be an important element of the development agenda post-2015. Global rural-urban inequities have shrunk but there are still considerable differences."*

As will be shown later, this is primarily due to the substantial difference in per capita development and service costs, in addition to the income differences.

In light of the goals of determining importance in terms of sustainability and development, it is astonishing that the closing document of the Budapest Water Summit (Szőlőssy Nagy and et al, 2019 p.1) couldn't but establish that ***"we are already off the track in implementing the water related SDG targets"***.

The closing document does not identify the cause for the digression or backlog. It calls to ***"Recognize the value of WATER in the fullest sense"*** in the first place. In terms of how, it points first of all towards "*developing cooperation at all levels*", and as its first pillar it calls for "***making information on policies, processes, and data transparent, timely and accessible to all people***". It then continues, indicating "***a radical reorientation of financing flows***" as a solution. Based on the above, the reasons for the digression and difference must be the inadequate level of awareness of decision-makers and society at large, as well as the resulting incorrect assessment and evaluation of the situation.

The increasing crisis of access to water is the result of the ambiguity in appreciating the value of water. Society in the broad sense regards access to water, a vital public good, as a **fundamental human right.** Political and economic regulators, on the other hand, **limit the transparent exposure and acceptance of the cost of infrastructure and background services** that are ensuring the protection of water resources in quantity and quality terms, as well as the supply to consumers, **through an affordability threshold, which is far below the total cost.**

Based on my professional career and information gained through studies over several decades, together with the knowledge of the relevant domestic and international regulations in force, of directives, methodological aides and professional literature, in full awareness of my responsibility towards the profession and society, I make the following statement: **knowledge, acceptance and recovery of the related costs**, the most important one of the conditions needed to meet water related sustainability goals, **is not fulfilled globally, within that in Europe and in Hungary either.**

In order to recognize and appreciate the value of water, even in the narrow sense, in order to develop adequate processes, regulatory systems and best practices applied at the level of the individual as well, and to radically regroup financing flows both in Europe and domestically as detailed later, **we need data, as well as social acceptance based on them, together with policy and political will!**

Before we engage in thinking and talking about abolishing the conceptual and practical limits of affordability and financing, **we need to get a clear understanding** of the costs related to the use of water resources, to water supply and to the protection of living waters (wastewater disposal and treatment), more specifically of **capital costs and their (non)recovery in the first place.** The clear understanding of the situation is hindered not only by the fact that relevant authorities and decision-makers, both at the individual and social level, lack the necessary data, or are unwilling to release such data, but also by the fact that **uniform indicators** to track costs and measure cost recovery **are missing.**

Although the WFD requires member states to release data on how they perform in terms of enforcing the full cost-recovery principle (European, Parliament and Council, 2000), data pertaining to cost-recovery per country are nowhere to be found on the webpage of EUROSTAT.

At one of the sessions of an EU benchmarking working group on the topic (Technical, 2013), I had the opportunity to glimpse into a summary chart on the related performance percentages of the individual countries, surprisingly, though, countries with higher tariffs reported non-full cost-recovery, whereas countries with minimum tariffs reported cost-recovery exceeding 100%. Consequently, these data are not released, as they do not allow comparison on a uniform basis.

The scope of the 2016 edition of the EUROSTAT Handbook on Environmental goods and services sector accounts (EUROSTAT 2016) does not include drinking water production, treatment, and distribution, as *"there is no clear boundary between the resource management activity aimed at preventing the over-usage of natural water resources and drinking water supply."*

According to the relevant literature and scientific research, *"it is a fundamental economic requirement that the price of a service has to be high enough at least to cover the costs of the service"*(Rogers, Silva and Bhatia, 2002a). Regrettably, up until this day, neither the EU's Committee on the Environment, responsible for the professional management of water management and for the coordination of the member states in this regard, nor its support organisations have succeeded in setting up a uniform indicator for cost-recovery and a methodological aid for its definition. This is due in part to the varying attitude of the commissioners in charge, in part to the resistance put up by the member states.

It has been suggested by many that the cost/value of water, as a resource will be difficult to define methodologically, substantiate in practice and have accepted by society (Roth 2001), thus throughout Europe, this value represents a mere 1% of water tariffs currently in effect. What few would have thought or realise even today, is that we can't seem to be on the same page in terms of capital costs, their recovery remains a futile attempt and in the majority of the newly joined, as well as in some of the earlier EU member states, service providers have to fight fierce battles to have even operating and maintenance costs covered. When it comes to the capital cost, requirements on how the depreciation of the infrastructure is reflected in the tariffs vary not just among EU member states but also among the individual federal states of the Federal Republic of Germany. The basis for the depreciation is the so-called historical value, i.e., the inflation-adjusted value upon activation (Historische Anschaffungs- und Herstellungskosten) in some federal states, whereas others use the present replacement value (Wiederbeschaffungswert) (Arbeitsgruppe Datenbank und Kostenkalkulation der Verbände BDEW und VKU, 2012).

Not even the International Water Association (IWA) bringing together water specialists from around the world, as well as the stakeholder professional organisations, has an indicator that adequately defines the costs of water management and urban water supply (Alegre, 2014). The accounts offering summary information on the statistical data of water supplies (IWA, 2014), also fail to reveal the cost structure underlying the individual charges and also fail to explain their recovery and the sustainability of supply and the infrastructural systems serving it.

In awareness of my social responsibility, which extends beyond my professional responsibility, I must also establish that as far as the sustainability of global systems is concerned, as things stand at the moment, not even the so-called weak sustainability criterion is met, as defined by Pearce and Atkinson (Pearce, 1993). A characteristic indicator that water resources are being exhausted is that the estimated volume of the total decline in global ground water resources is 283 (+/- 40) km^3/year (Yoshihide Wada et al, 2010a). Upon the global and drastic impairment of water-related environmental system services, exceeding USD 20 thousand billion annually (Ramsar Briefing, 2015), not even the maintenance, replacement and preservation of the capital value of the infrastructure already built in part can be ensured.

My latter claim is evidenced by the fact that the depreciation as the source for covering replacement, created from the capitalisation value of the investment calculated in accordance with the most common, internationally accepted accounting principle, is largely losing its purchasing power in consequence of inflation in the case of 30-50-100 years old infrastructure assets. Even in the case of a consolidated 3% rate of inflation, the annual depreciation of a facility intended for 50 years loses more than 50% of its purchasing power by the middle of its expected life. By year 50, i.e., in the given year 77% is lost, that means less than one quarter of the original value or of the pipe section, for instance, in non-financial, quantitative terms, can be replaced. In Hungary, the Hungarian Forint suffered a double-digit inflation in the early 1990s. The 22 years between 1990 and 2012 resulted in a cumulative rate of inflation of nearly 1200%. For public utilities built in or before 1990, this means that the depreciation for the capitalisation value (gross book value), (provided that such depreciation is accounted for and enforced in the tariffs, see below), covers a mere 8.3% of present replacement costs. In addition to inflationary depreciation, the obsolescence of the water utility infrastructure is also to be reckoned with. Consumption values have declined substantially, domestic water consumption has diminished by half, industrial consumers have been lost. New, in part more stringent EU quality limit values have been adopted. The above combined effects have called for a comprehensive stocktaking and (re)valuation of the infrastructure (Hungarian Parliament, 2011a).

These years saw the preparation, engineering and financial planning of hundreds of urban utility development projects of the first programming period (2007-2014) following Hungary’s accession to the European Union. These projects involved a wide range of actors of both the sector and of society at large. The process was aided by multiple methodological and thematic developments. Under my professional guidance, specific unit cost indicators were determined, allowing the estimation of the expected cost of the planned projects, as well as the monitoring of the budgets proposed (Kovács and et al, 2009). The investment cost indicators covered the entire range of urban water utility types (ranging from water extraction to wastewater treatment).

Upon my initiative and with my professional involvement, the dynamic cost comparison (DCC) methodology (EWA, 2011a), allowing the cost effectiveness analysis of development scenarios and thereby the selection of scenarios with the least total cost, calculated on the basis of full life-cycle cost, was incorporated into the EU system of subsidies and disseminated. Under my professional guidance, a methodology for the valuation of utility assets, based on and synchronised with the above and the supporting TIKA – MIAD software (Kovács and et al, 2010) were developed and disseminated domestically and within the region.

The results of hundreds of the water utility development projects implemented in the meantime and the valuation of nearly 2000 urban communities water infrastructure are available and have allowed us to conduct the part of this research pertaining to the characteristics of infrastructure costs.

A database for the purpose of assessing and analysing affordability, willingness to pay and to engage in solidarity as needed was created within the HWA VALUE OF WATER research carried out upon my initiative and under my professional guidance. Since earlier there were no similar, comprehensive research projects, my questions aimed at assessing inclination for solidarity were integrated into the focus group-based research entitled HWA VALUE OF WATER – Water in the household, public perception of water supply, wastewater treatment and into a survey conducted on a sample of 5000 people and then adopted for my analyses from the database thus generated (MASZESZ, 2020). The final integrated database was completed by the data adopted from the sample of 5000.

1.2 Precedents of infrastructure development and maintenance situation

The infrastructure forming the backbone of urban water utility services (water supply and wastewater disposal, collectively) encompasses in Hungary a network of pipelines, the length of which equals 3-4 times that of the equator and is, **based on data released by official sources, showing considerable differences, 117,308 kilometres (KSH, 2019a)**(KSH, 2019c), or **164,000 kilometres** (MEKH, 2019b)**.** The length of the European water supply network is 4,225,527 kilometres (11 times the distance between the Earth and the Moon) (EurEau, 2017a). Differences in the domestic data supply raise recurring issues within the national data-supply towards the EU for statistical purposes, also affecting the credibility of data supply. The differences are in part due to the dissimilar and non-harmonised data supplied by the data supplier towards the individual institutions and government agencies (municipalities, utility companies). The magnitude of the difference suggests the inconsistency of the classification of the water mains in the street and the so-called building lateral pipes that branch-off to the individual properties but are still managed by the utility service provider and the inaccuracy in the property inventories.

The differences in the official database exceeding the length of the equator would themselves deserve a research into the topic. At the same time, as will be seen later, the sector, water management agencies and society have to resolve issues far beyond the definition of the length of the pipeline, having to do with asset and property management, development and maintenance.

Modern urban water utility services in Hungary go back 150 years. Water supply and wastewater management were developed in the individual urban areas at different speeds, using the financing sources available and subject to the investment approach available at the time, using varying technologies and diverse materials.

Initially, most of the waterworks were community (municipally) owned and the overwhelming majority of water management developments were implemented using "municipal bonds". Banks at the time were willing to lend for as long as a 50-year term and offered high amounts of financing. *"The amount of annual repayment depended on the amount of the loan, its interest and maturity and had to be repaid from water revenues, inclusive of the operating costs." ."* (Füstös, 2010p.30) It should also be noted that with a 3% interest rate the annual repayment instalment amounted to approximately3.9% with a 50-year maturity and about 5.7% with a 25-year maturity. For many years, at least in a stable economic environment, this form of development equity financing worked as a sustainable model financed through service charges. The amount of the cost of capital and its recovery and affordability should be compared to the 2% expected but not materialising in the subsidy system referred to in Chapter 1.1. Considering the difference, a scrutiny of today's approach to financing and value, as well as of the cost effectiveness of today's developments is inevitable.

"Until 1944, 45 towns and 192 villages had either central waterworks or "district" waterworks that supplied a portion of the settlement." (Füstös, 2010) It is both interesting and worthwhile pointing out that *"In order to secure revenues, in the case of community-owned waterworks, owners of properties alongside the pipeline were bound by regulations to connect onto the water mains and at the same time to pay a flat-rate water charge levied on the basis of the number of rooms in the dwelling. Payment of the water charge was mandatory not only for the owners in possession of a domestic connection, but house owners in streets without pipelines*

also had to pay a reduced flat-rate charge. Residents within 250 metres of public hydrants were considered as supplied and were thus liable to pay water charges." (Füstös, 2010, p.29.)

In the majority of our cities, water pipelines and sewerage network sections aged over 100 years are still in use. (Juhász, 2012)

Initially, cast iron and clay pipes were used for the pipelines with a longer lifespan (exceeding 100 years). Later on, for systems implemented under the auspices of the planned economy, lower-cost materials, such as concrete, reinforced concrete, steel, PVC and asbestos-cement were typically used. Nearly 50% of the public utility water pipeline network currently in operation is made of asbestos-cement. The planned lifetime expected upon construction of the more recent systems is 50 years. (MAGYAR MÉRNÖKI KAMARA, 2009) Actual and useful life are subject to the influence of a number of other factors (quality of construction, receiving soil, water quality and pressure conditions, other loads), thus their obsolescence and renovation needs show substantial variation in time. (Kovács, 2009)

Following the change of regime, urban water utility infrastructure has been subject to the provisions of act XXXIII of 1991.

"Urban water utilities managed by non-municipally founded regional water utility companies, providing water utility services to one or more urban areas of non-regional purpose, provided that those can be operated in a way that can be technically separated from the regional utility network, will be transferred by the metropolitan and county government offices to the ownership of the local governments of the urban settlements involved.

Local governments owning water utility assets shall provide for the professional and safe operation (maintenance) of the water utilities in compliance with the regulations, as well as for the ongoing delivery of public services, and for the necessary developments of the utility works.

Water utility works form part of the core assets of local governments with limited marketability and can only be used for public service purposes." (Parliament of Hungary, 1991)

Although local governments were responsible for the necessary development of the public utilities, in consideration of their lack of funds, substantial water utility development subsidy programmes were launched using targeted and earmarked central budget funds.

In 1990, the number of urban settlements with piped drinking water was 2,431, which increased to 3,144, nearly 100% by 2004. The number of dwellings supplied increased from 3.3 million to 3.9 million, which meant that the ratio of dwellings connected to piped water supply increased from 85% in 1990 to 94% in 2004. The number of urban settlements with a public utility wastewater collection network was a mere 429 in the entire country in 1990, which increased to 1,392 by 2004 and to over 2,100 by 2018. The percentage ratio of dwellings with a sewerage connection increased from 41% to 62% by 2004 and to 82% by 2018. A particularly noteworthy change is that while in 1990 a mere 3.2% of dwellings in villages were connected to the public sewerage network, as opposed to 65% of dwellings in cities, the level of supply in villages rose to 32% by 2004 and to over 50% by 2018. (KSH, 2019b)(KSH, 2019d)

Additional developments occurred following Hungary's accession to the European Union. For the newly joined countries the European Union offered substantial development aid (primarily for the establishment of new infrastructure), in order to facilitate compliance with the common water supply and environmental regulations. The development programmes were implemented in multiple phases (meeting different deadlines) depending on the size of the settlements. The necessary water utility infrastructure was developed in the larger urban areas (exceeding 100 thousand inhabitants) first and was then gradually followed by smaller settlements (all the way down to villages of 2,000 inhabitants and agglomerations of up to that number of inhabitants). The reason and explanation for the phased implementation are economy of scale considerations and cost effectiveness related to the environmental impact.

A statistical correlation merits attention at this point, namely that the data of the KSH referred to earlier in the context of sewerage network development, lend themselves to easy calculation that while in 1990 there was an average of 135 dwellings for each 1 kilometre of sewerage pipeline, this figure declined to 72 on average by 2018. The number of additional dwellings per newly built sewerage pipeline is on average less than 53 service connections/km. (KSH, 2019b) In other words, this means that while in larger urban areas 7.4 running metres of sewerage pipeline per dwelling were needed for the service connection, for more recent developments in villages this ratio increased by 255%, to 18.9 running metres/dwelling.

EU subsidies and the determining portion of the related subsidy stemming from domestic co-financing are non-repayable by the beneficiaries. Compliance with the eligibility criteria and the level of subsidy are determined on the basis of means-testing and sustainability considerations. To back these decisions, a so-called cost-benefit analysis (CBA) was required for each project (EUROPEAN, 2014). One important requirement, upon which eligibility was hinged was that the facilities to be implemented and the services to be provided using those facilities should be sustainable, i.e., the funding for the replacement of the resulting assets should be covered by the service charges! It is worth noting here that for network development projects, compared to the model prevailing 100 years ago, this requirement is equivalent to a 0% interest financing with a 50-year maturity if materials of inferior quality are used and with a maturity of as much as 100 years, if materials with a longer lifespan are used. Accordingly, against the earlier 3.9-5.7% annual "repayment rate", the capital cost would be a mere 2% or 1% of the investment cost. The significant difference being that with loan repayment the funding for the next replacement investment is not actually generated (the payment goes back to the financing institution), whereas the EU requirement actually provides for that as well (the collected depreciation stays with the beneficiary and can be used for the replacement). Through the financial commitment of those implementing the development, cost-sensitive, rational investors create value for future generations in the first case, whereas in the latter wasteful beneficiaries of subsidies pass on often irrationally high maintenance costs to future generations. They can and will do so, because due to the inaccuracies of the regulatory environment, the lack of appropriate indicators and as a result of false value perception and expectations of society, current tariff calculations provide either no or only marginal funding for asset replacement.

The CBA guidelines also allowed the beneficiary countries and urban settlements to enforce an affordability threshold for the payment obligation of the consumers involved. The threshold value is 3% of the income of the households affected. If the charges including depreciation (funding set aside for replacement) should exceed the above 3% affordability threshold of household income as a result of the projects implemented using EU subsidies, for assets with a longer useful life deferred depreciation can be applied. In this context, it is important to know that during the term viewed for the CBA calculation (30 years), the depreciation applied in the tariff, (would have) increased the income of beneficiaries, which (would have) reduced their apparent need and thus the ratio of the subsidy. Such effect reducing the subsidy ratio (would have) applied in spite of the fact that using the present value calculation as per the methodology, on a 30-year time horizon, the present value of future costs is reduced to one quarter upon the earlier used 5% discount rate. By deferring or in multiple instances fully neglecting the depreciation of high value new investments, charges could be kept low and the subsidy ratio could be increased, while no funding is generated for the renewal of either the new facilities in the long-term or for the urgent renovation of the existing ones. The effect, which albeit moderate but still reducing the subsidy ratio, is offset by the utility valuations carried out in the meantime. These can provide a real value documentation of the projected replacement time of existing water utility infrastructure, which could be taken into account for the use of free cash flow potentially generated by the new facilities.

It might make sense to note at this point that although when it comes to affordability, water and sewerage charges are treated as one whole by both EU and domestic regulations (the 3% household threshold is set for their combined value), in terms of cost accounting, though, both regulations call for sectoral delimitation. Existing facilities and those realised through development within the individual sectoral systems can be taken into account in a uniform fashion.

This will be of particular significance, as will be seen later on, due to the difference in timing of the implementation of water and wastewater sectoral infrastructure, their replacement needs will also arise at different times and to different extents. The prohibition of cross-financing between the two makes balancing asset and tariff management, as well as the distribution of unevenly spread replacement needs more difficult and in the majority of cases, impossible.

At the same time, the chapter on urban water management of the National Water Strategy (Government of Hungary, 2017) also points out that *"the single greatest challenge of urban water management is the backlog in the reconstruction of water utilities and the extremely low rate of affordability"* and that *"the cumulative backlog in reconstructions calls for additional interventions."* This also highlights the importance of economic factors.

The total replacement value of urban water utility infrastructure, seen as if it had to be built or renewed today, amounts to some HUF 10 thousand billion (Somlyódy, 2011) (calculating with a 350 HUF/€ exchange rate: nearly € 30 billion).

To illustrate the magnitude and weight of this value, it should be noted that **to cover the replacement costs of the entire portfolio of assets,** based on the above value and with an expected useful life of 50 years and a 2% depreciation, **HUF 200 billion/year would be needed.** This value could be higher because of a higher rate of depreciation for assets with a shorter lifecycle, at the same time, **it accounts for about 80% of the total annual revenues of the current urban water and wastewater services!** On this basis, under the current circumstances, total cost recovery is obviously out of the question, as explained and discussed in detail later on, and so is sustaining the value of the infrastructure!

In terms of the service revenues and the funding generated within those for asset replacement, it can be concluded that the (depreciation, asset utilisation fee) replacement, development ratio generated within domestic service charges is very low by international standards. The 11% rate of the 2010 service tariff revenue already puts us well behind the German and Swiss rates of 45% and 69% respectively. (Kovács, 2010) This ratio deteriorated further since the tariffs were frozen in 2012 and reduced in 2013, because of the increase in other cost elements (wages, energy, etc.). Its current level according to a study commissioned by the Infrastructure Federation, is 7.5%. (Vékony, 2018)

Based on the above data, in a tariff regime providing cost recovery, even upon balanced distribution, tariffs should be at least doubled in order to provide funding for replacement. Countries operating in an economic and infrastructure environment more advanced than ours also make similar conclusions. In the United States, for instance, a comprehensive study assessing maintenance and development challenges projects a threefold increase in service charges due to the increasingly pressing renovation and development needs. (American Water Works Association, 2010) At the same time, as is suggested by the above study and as can be seen based on the findings of the research, replacement needs vary greatly in time, by sector, urban settlement and by the groups based on the size of the settlement. Especially in villages with fewer inhabitants, replacements are even more significantly underfinanced as a proportion of the service charges. The backlog and accumulation in reconstruction works at the same time increase maintenance, trouble shooting and water losses, which in turn leads to the increase in service costs and the decline in the safety of supply.

The ratio of needs and funding sources clearly shows that service charges do not provide funding for the maintenance of the infrastructure, a man-made capital. The lack of funding for replacement also means that the intergenerational maintenance obligation is not met, since the obligation to replace infrastructure inherited from our predecessors is passed onto our descendants. (Kerekes, 2010a).

Natural characteristics, societal needs and the state of the infrastructure developed earlier, factors determining the activities within the sector, show a heterogeneous landscape within the country. (SZÁZADVÉG, 2016) Subsequent chapters of the study explore their underlying causes, and the factors influencing them.

1.3 Factors underlying the subject matter of the research, precedents, database

Act CCIX of 2011 on water utility services (Parliament of Hungary, 2011b), the Hungarian water utility regulation, which is unique and forward looking in many respects, by international standards as well, requires that all actors responsible for the supply (owners of the utility infrastructure: the state and the municipal local governments) have to perform a full, comprehensive and itemised stocktaking and re-evaluation of all water utility assets. The original deadline was 2015, first modified to 2019 and then to 31. December 2022.

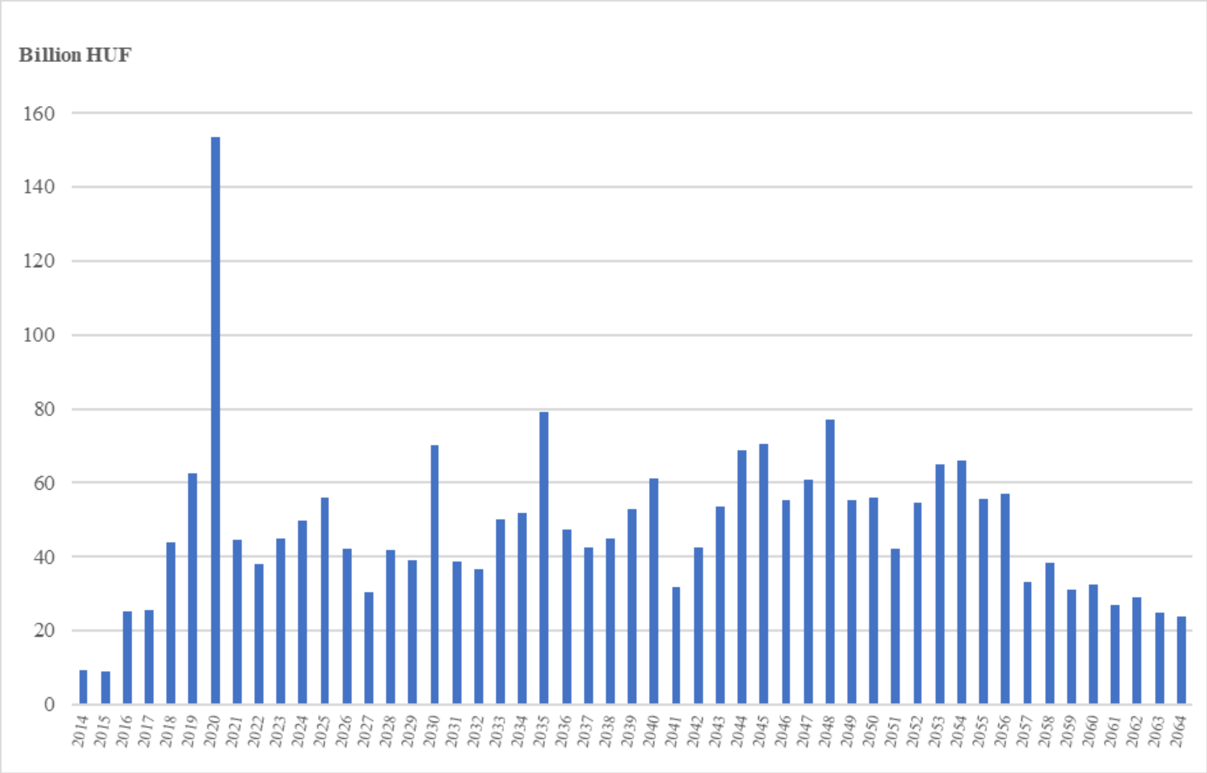
One of the reasons for this was to eliminate the impairment caused by the substantial cumulative effect (1,300% inflation between 1990 and the present day) on the historical/capitalisation costs of assets (objects) built at different times over past decades. By creating a uniform asset inventory and determining the extent of functional and economic obsolescence, development can be planned (GFT) in a way that supports cost effectiveness while at the same time ensuring the maintenance and upkeep of the assets and the differences in the official sectorial asset records, the size of the equator, mentioned earlier could also be dealt with.

The asset valuation process is yet to be concluded, even though the deadlines have already passed. As of the time of this research paper, the water utility data of more than 1700 of the 3155 Hungarian urban settlements are already available in the Multipurpose Infrastructure Assessment Database (TIKA - MIAD) software (Kovács and et al, 2010) in a uniform and searchable database.

This MIAD database developed under my professional guidance and leadership, contains all water supply (from extraction to the distribution network), wastewater discharge and treatment infrastructure facilities and objects located in the administrative area of the individual urban settlements, in accordance with the relevant regulation.

In the course of the evaluations, in addition to the objects and their territorial identification data, technical parameters (diameter, material, construction depth, etc.), as well as the data pertaining to the status review (level of obsolescence, expected lifetime) and to the economic evaluation (replacement and asset value) have also been recorded, amounting to a total of 20 data per object.

The infrastructure replacement values summarised per year can be generated for the supply areas using the tens of millions of data items of the several million objects, broken down by urban settlement, water and wastewater sector and linear (pipeline) and point-like facilities. These data lend themselves for diverse data processing and research possibilities. The data lines for yearly replacement cost per urban area characteristically indicate replacement needs for the 50 years following the valuation, expressed in monetary (HUF) terms and shown in an annual breakdown (see Fig. 1. Total replacement needs of water utilities of urban areas shown in the TIKA nationwide database, for the period 2014-2064, bar chart, as per 2015)



1. FIGURE: TOTAL REPLACEMENT NEEDS OF WATER UTILITIES OF SETTLEMENTS SHOWN IN THE MIAD NATIONWIDE DATABASE, FOR THE PERIOD 2014-2064, BAR CHART (AUTHOR'S OWN FIGURE)

2. Subject, basis, objective of the research

2.1 Subject of the research:

The subject of this research is the study of the per capita, i.e.,, the smallest unit of society, aggregate replacement cost (OPK/pp) of the water utility infrastructure providing urban water and sewerage services and its influencing factors. The research was conducted by urban settlements grouped by size, exploring the distribution over time, funding sources, and affordability of per capita costs. I also looked into the willingness of the individual to assume social responsibility and the attitude towards solidarity among generational and settlement groups.

2.2 Basis of the research

The research is based in part on the 714 urban settlements included in the TIKA-MIAD database, where there is both water and wastewater utility. The database can be queried for structured economic data summarised by sector and object group, showing the annual replacement needs, which can then be used for further statistical evaluation and analysis. I then coupled these data with the number of inhabitants in the given urban area, the water and wastewater service charges levied there, as well as the length characteristics of the supply pipeline, as well as their county (regional) affiliation and additional identification codes together with other data facilitating evaluation and analysis. In addition to the research into the infrastructure forming the basis for urban water utility service and exploring issues related to asset management, I focus on the attitude of society towards Water-Value, more specifically the willingness for social engagement in vertical solidarity (overarching multiple generations), as well as the horizontal solidarity attitudes of those living in the different individual settlements and regions.

My questions intended to measure willingness for solidarity were incorporated into the focus-group based research “HWA WATERVALUE - Water in the household, domestic perception of water supply and water treatment” and into a survey conducted on a sample of 5000 people. The databased thus generated (MASZESZ, 2020) was used for further research and analysis.

2.3 Research objective

This research is consistent with the special research tasks of the Hungarian Academy of Sciences (MTA) defined in 2018 on equal opportunities considerations of water supply. These tasks include:

The development of solutions for the simultaneous fulfilment of the principle of full cost recovery and of the affordability of drinking water

Universal, in the long-term sustainable access to drinking water, including socially marginalised people – identification of legal, engineering and financial solutions (MTA, 2018)

In this spirit, the purpose of the current research is to quantify, reveal and formulate science-based recommendations on

- The extent of the difference in urban settlements of different sizes, grouped by size, between specific costs per capita or per single unit of consumption of the development and upkeep of infrastructure on which water utility services are based, and to what extent is funding provided for these through the tariffs used in the various urban settlement groups,
- The factors influencing per capita replacement needs and the correlation between the size of the urban area, specific costs and the income level of the inhabitants,
- The extent to which the polluter pays and the cost recovery principles and the right to healthy drinking water and sanitation are enforced under the current framework of affordability/willingness to pay, and how these can be reconciled with the requirement of sustainability,
- The social engagement needed and solidarity requirements arising out of ensuring universal and sustainable in the long-run access to drinking water, including to those socially marginalised and those living in small villages, in light of the considerable differences and disparities in water infrastructure development and replacement needs, manifest by urban settlement size groups,
- The extent to which people living in urbans settlements of different sizes perceive the difference in the costs of water utility services and to which people are willing to engage in or expect society's engagement and solidarity in the interest of ensuring universally accessible and sustainable water services,
- What asset management measures can be taken to ensure that the planning of the development and replacement of water utility infrastructure and thereby the fee structure is more balanced and more sustainable among the various urban settlements and settlement groups,

3. Development and maintenance of water utility services, literature review and hypotheses on the matter

In the following sections, the principal links between the development and maintenance of water utility services are reviewed, together with the basic principles and the key findings of research relevant to the topic, as shown in domestic and international examples. A separate section is dedicated to reviewing the Hungarian and international literature on the topic, including the interpretation of basic human rights related to water, the characteristics of the cost structure of water utility services and the theoretical and practical elements and methods of the management of public utility assets and the issues of social responsibility related to the field.

3.1 Granting and maintaining the fundamental human right to water, quality and quantity requirements, supply scenarios.

On 28. July 2010, through Resolution 64/292, the United Nations General Assembly explicitly recognised access to healthy drinking water and sanitation as a fundamental human right. The Right to Water is also essential to the realisation of all human rights (UN GA, 2010). The road to progress was long and bumpy (UN-WATER-DPAC, 2011) and this right is interpreted by many in many different ways. (Szilágyi, 2015) On two things, though, almost everyone seems to agree:

- This is not equal to the right of access/use free of charge, see (OECD Multi-stakeholder declaration, 2015), (European, Parliament and Council, 2000), (UN SPECIAL RAPPORTEUR, 2017) and the millions of signatories of the European Citizens' Initiative (Citizens, 2012), and Ireland, which abolished water and sewerage charges in 1997 (Duffy, 2016a),
- At the same time, each and every member and layer of society cannot be expected to pay, for instance, a fee that covers "full cost recovery" payable by the user/polluter as per paragraph 9. of the European Water Framework Directive (European, Parliament and Council, 2000). It is worth noting that the EU-WFD itself identifies exemptions and concessions based on social considerations.

In its Goal No. 6., "Clean Water and Sanitation", in the context of the "Sustainable Development Goals – SDG", the UN Development Programme sets the target that by 2030 "Safe and affordable drinking water should be universally available," and that "Sustainable water and wastewater management should be available to everyone" (UN DP 2016). In addition to the right to water, the fulfilment of the water-related sustainability goals is essential for a number of other SDG areas, as well. What kind of access are we talking about in terms of **quantity, quality and in what form**, which also has to be affordable and sustainable? **Quality requirements** for drinking water are regulated in the regulations of the UN World Health Organisation, taking into account the characteristic features of the various water sources and supply systems, as well as other local characteristics (WHO, 2011).

Views vary when it comes to the **quantity of water** needed for healthy life with human dignity. In 2002, in its comments on the right to water, the Committee on Economic, Social and Cultural Rights of the UN Economic and Social Council (UN-CESCR, 2003) mentions a volume of 20 l/person/day. In the publication, in turn, written by the special rapporteur appointed by the UN on the issue of rights to water, the clear and definitive answer to the question, whether the 20 litres/person/day volume can indeed ensure that the right is enforced, is "NO". *"Access to 20 litres of water/person/day represents a minimum, but this amount still leaves substantial health concerns. To ensure that the right is fully enforced, states would need to strive to provide at least 50-100 litres of water/person/day."* (UN SPECIAL RAPPORTEUR, 2017)

It must be noticed that the above quote refers to "water" and not "drinking water". This quality distinction leads us to identify and analyse in our immediate and broader surroundings as well, different scenarios (water supply network, wastewater treatment, private wells, wastewater management, bottled water supply, partial transport by road, partial recycling, alternative water sources, e.g.: rainwater harvesting) in response to the third question, regarding the **form of supply**, depending on the available water sources, in view of the supply infrastructure and the asset requirement.

When evaluating these variants, it is essential to bear in mind the possibilities for water supply and for the drainage, treatment, and reuse of treated wastewater, as well as the needs of other consumers (manufacturing industry, agriculture) competing for these, in light of their interactions. At the same time, development and maintenance of urban water management has to be implemented within the framework of integrated water management, which means that *"the measures taken to ensure that environmental, economic and social goals related to the use and protection of water resources are met, have to be formulated and implemented in a concerted manner"* (IJJAS, 2019)

In this context, it is important to point out that the analysis of our current possibilities and the decisions have to be conducted in a forward-looking manner, in consideration of the continuously changing needs (population, economic growth) and circumstances (climate change) on the one hand, and of the long lifecycle (50-100 years) development of the subject matter of our decisions, on the other.

Global forecasts for both quantity and quality needs of water consumption and the costs of infrastructure development capable of serving the growing demand, show clear and considerable growth. There are substantial differences in the extent of growth, due to the countless factors of uncertainties and to the different bases for projection.

According to the scenarios reviewed by the OECD, by 2050 demand for water will increase by 55% globally (including agricultural water consumption as well, which currently accounts for more than two thirds of current water extraction). Within that, household water demand will increase by 130% and industrial consumption related partly to urban water systems will grow by 400% (OECD-WWC, 2015)

Conversely, according to the model calculations for the same period of the International Institute for Applied Systems Analysis (IIASA), based on estimates for different scenarios, household water consumption will increase by 50%-250%, whereas industrial consumption will grow by more than 200%. (IIASA, 2015)

Based on these estimates, the cost of water infrastructure developments during the period 2013-2030, will be USD 11.7 thousand billion (IJJAS, 2019). Ijjas also suggests that one of the reasons for the differences between the cost estimates for the infrastructure necessary to create a world with water security lies in the differences between the narrower interpretation of water security, limited to drinking water supply and sanitation security versus a broader understanding that includes the risks associated with the abundance or scarcity of water and with contaminated water.

The STRATEGY+BUSINESS Study (Doshi, 2007), also referenced by the UNEP, forecasts USD 22.6 thousand billion, i.e., double that figure, for urban water utility development during the period 2005-2030. This projection differs from the previous one in two regards: on the one hand, it focuses on urban water supply and wastewater treatment infrastructure in the narrow sense, and of the types of urban settlements, it looks at infrastructure development of cities only, its calculations, however, encompass the renovation of already existing but largely obsolete infrastructure of the developed world, on the other. To illustrate the order of magnitude of the sum of USD 22.6 thousand billion, this inconceivable amount should be compared to the USD 18.6 thousand billion projected for the same period and for the same urban areas for the development of other infrastructures (road, railways, energy supply, maritime ports and airports)! The sectoral comparison shows, surprisingly at first glance even for specialists of the water sector, that the development needs of the water utility infrastructure alone exceed the combined needs of all other, above mentioned infrastructure types!

In spite of the uncertainties of the various estimates, WWC and OECD, as well as the high-level panel (UN HLPW) established by the UN and the World Bank for the development of the water sector, conclude that a substantial increase in the current funding for development, according to the summary recommendation of the latter body, at least double the amount will be needed. (UN HLPW, 2016)

A number of global and regional fora and studies find that equity investment will in part be the funding source for preventing the water crisis (Kolker, 2018) (KPMG, 2011) (UN HLPW, 2018). To illustrate the weight of the USD 41 thousand billion, the amount of infrastructure development, it is important to note that this is the same order of magnitude as the total equity value of stocks traded on all stock exchanges of the world in 2006. (Doshi, 2007) In light if the latter comparison it is questionable, whether upon the return on capital (or lack of it) experienced in water utility services (as defined later), private equity investors are at all ready to assume the opportunity costs of the return on capital expected/attainable in the water sector and in other areas of the economy. My doubts in this regard are amplified by the results of the survey, in which the overwhelming majority of international experts asked within my research conducted under the auspices of the European Water Association (EWA) think that *"private equity cannot be expected to offer a replacement in substance for the central budget and municipal financing of capital-intensive water utility infrastructure developments."* (Kovács, 2020)

The study of UNEP conducted in 2013, has important findings, noteworthy for future analyses, regarding cities accommodating the majority of global population. According to the study, some 80% of global GDP, global economic production of consumption is concentrated in a mere 2% of the land areas of the globe, which at the same time consume 75% of the world's energy and material flows (Swilling *et al.*, 2013b). Making urbanisation processes sustainable is subject to a number of conditions, and to the collaboration and substantial financial commitment of those involved, including governmental and social actors. The study fails to even mention supplying the lower-income population living outside of cities, representing some 50% of the world, as well as their lower cost-effectiveness infrastructure development needs and potentials.

One of the key conditions for sustainable growth would be fostering water security. (IJJAS, 2019) Direct economic losses suffered as a result of the lack of water security amount to USD 470 billion annually. (UN HLPW, 2016) The global impairment of water-related environmental services amounts to USD 20 thousand billion/year, (Gardner *et al.*, 2015), which is twenty times the annual infrastructure development needs! In light of these comparisons, sustainability and development pointing towards sustainability remain elusive.

Even though the sustainability of development has multiple, much quoted definitions formulated by many, sustainability remains difficult to define, since it is a fundamentally vague and complex concept. (Phillis and Andriantiatsaholiniaina, 2001)

Kerekes distinguishes among three basic types of the concept of sustainability:

1. *Sustainability can be interpreted as constant consumption. This interpretation meets the weak sustainability criterion, in which natural and man-made capital are interchangeable. The standard of total production and per capita production can be maintained as long as the profit generated by the use of natural resources is invested into material capital rather than consumed.*
2. *Sustainability can be interpreted as the constant (in time) set of natural resources. This interpretation lends itself to sustainability in the strict sense and presupposes that natural and man-made capital complement but do not replace each other.*
3. *And finally, sustainability can be interpreted as equality between generations. The latter interpretation is different from the former two in that it makes no stipulations regarding the replaceability of natural vs. man-made capital, instead it places the vaguely defined requirement of "some sort of equality between generations" into the centre.* (Kerekes, 2010a)

"The third definition, that of the Brundtland report, has no meaning, economically speaking, which explains why although the definition can be discussed, it cannot serve as the basis for practical environmental policy. It is probably no coincidence that this least tangible concept is the most widely known one." (Kerekes, 2010b)

The first two definitions lend themselves to be described as economic categories. The second definition, that of sustainability in the strict sense, although an economic category, however fails to provide a criterion that the existing economy can comply with and it can at best be attempted to find an approximation through a certain "safe minimum standard"-type regulation (Kerekes, 2010b).

Based on the Ramsar Briefing, upon the worldwide and drastic impairment of environmental resources, more specifically water-related environmental services exceeding USD 20 thousand billion annually (Ramsar Briefing, 2015), it is safe to say, that this is definitely not fulfilled and in this sense we are clearly moving on an unsustainable track.

Within weak sustainability, Pearce and Atkinson distinguish between three types of capital: man-made (or reproducible) capital (roads, factories, dwellings, water utility infrastructure, etc.), human capital (accumulated knowledge and experience) and natural capital, all of which are interoperable, and sustainability can be achieved by sustaining the value of their sum.

Knowing, but not accepting, though, that our natural resources (Gardner *et al.*, 2015) and water resources (Yoshihide Wada et al, 2010b) are about to be exhausted, **the evaluation conducted within the present study is intended to answer whether the present generation will at least provide for the sustaining the man-made water utility infrastructure, the subject matter of this study, as a capital item.**

I must emphasize, as have done all sources cited so far, that an essential condition for the protection of water resources and for the sustainability of water management, alongside with the provision of drinking water and other domestic water, is the proper collection, drainage, transport and treatment before the release into the natural environment of polluted waters.

Collection, drainage, and treatment of urban wastewater is regulated by the European Community in it Directive 91/271/EEC on urban wastewater management. The purpose of the directive is to protect the environment and within that living aquatic resources, surface and ground water resources from the harmful effects of urban and certain industrial wastewater discharges.

The first paragraph of article 3. of the directive provides that *"member states shall ensure that all agglomerations with a p.e. over 2000 are provided with collecting systems for urban wastewater"* (EEC COUNCIL, 1991a). The "collecting system" according to paragraph 5. of Article 2. of the Directive is "a **system of conduits**, which collects and conducts urban wastewater". It should also be noted that the Directive also allows for alternative solutions: *"Where the establishment of a collecting system is not justified either because it would produce no environmental benefit or because it would involve excessive costs, individual systems or other appropriate systems, which achieve the same level of environmental protection shall be used."*

It is important to point out, because of the subject matter of the research (in this instance urban settlements of varying size), that the regulation makes considerable concessions for smaller settlements, settlement groups and agglomerations in terms of both drainage systems and the wastewater treatment regulated in article 4. of the directive. For smaller urban settlements, the regulation sets a delayed compliance deadline, and in terms of the efficiency of treatment, tertiary treatment is not required and no Nitrogen or Phosphorus limit values or removal are required for urban areas with a p.e. of less than 10.000, even in vulnerable areas under increased protection (EEC COUNCIL, 1991b).

The reasons for the concessions are not given either in the directive itself or in the "guide" to the "Terms and definitions of the Council Directive 91/271/EEC concerning urban wastewater treatment" (EU MS WG, 2007). At the same time, the Information issued by the Ministry of

Interior on the National Implementation Programme of the Directive makes a generally accepted observation underpinning the significance of the research: *providing utilities to population situated in a more concentrated space can be done more efficiently at lower cost* (BM KVHÁ, 2014a). This shows that one unit of expenditure results in greater environmental benefit and it makes sense (i.e., it is more cost effective) to start with the larger polluters.

"Other" supply solutions (individual solutions, transport by road, bottled supply, storage and use of rainwater, solutions with partial, potentially multiple reuses, depending on consumption, etc.) should form the subject matter of further papers. To be able to evaluate the cost effectiveness of "other" solutions and to compare them with the network solutions, the cost management relations of network infrastructure and service environment characteristic for areas with advanced water utility infrastructure have to be revealed in the first place.

The 50-100 litres of water/person/day referred to above are largely equivalent to today's Hungarian domestic water consumption figures. Per capita public utility drinking water consumption shows a declining tendency as the size of the urban area diminishes and as time passes, in line with other countries in the region. (Papp, 2007) (KPMG, 2015) (SZÁZADVÉG, 2016) Unless we wish to take a step back from the level of domestic water utility supply as a first approach, the service clearly needs pipeline infrastructure, which involves significant development and maintenance costs.

3.2 Cost structure of water utility service and full (non)recovery of individual cost items

60% of European cities deplete their ground water resources through gradual "overexploitation". A substantial portion (in many cases exceeding 50%) of the water extracted and pumped into the distribution networks never reaches consumers because of network leakages and burst pipes.

Pursuant to paragraph 9. of the WFD (European, Parliament and Council, 2000), the control and management of water usage represents a legal obligation in all areas of water usage, to ensure the sustainable use of water resources. Improving the efficiency of water use and water services is a precondition for meeting this objective. (EEA, 2003)

According to the WFD, the user/polluter shall pay a fee that provides "full cost recovery". In 2001, shortly after the adoption of the WFD, EEA, an EU institution defined the term of full cost recovery, identifying seven items for the cost items to be considered: I. Cost of operation and maintenance, II. Cost of capital, III. Opportunity cost, IV. Cost of natural resource (VKJ), V. Social cost, VI. Environmental cost, VII. Long-term marginal cost.

Such interpretation of full cost recovery and considering and taking into account all of the above cost elements in full would mean that the projected cost of (I.) day-to-day functioning and operation (extraction, treatment, distribution, collection and treatment after usage), of (II.) financing and interest costs of the necessary infrastructure investments, of (III.) the opportunity costs of the return on capital expected in the water sector and in other sectors of the economy, of (IV.) the use of natural resources stemming from the scarcity of water resources, of (V.) social costs caused to others through certain types of usage, of (VI.) the costs of the damage caused to nature as a consequence of water usage, and of the long-term appreciation of natural resources and environmental damages would also need to be reflected in the tariffs. (Roth, 2001)

Roth immediately adds that the practical implementation as per the above of the principle of full cost recovery would cause serious difficulties, therefore the implementation, enforcement and continuation of the concept of full cost recovery will be a task for the near future…

Regrettably, even though 20 years have passed since the above definition surfaced, there has been no major progress either in the methodological aid regulating uniform interpretation, calculation and reporting obligations, or especially in recovering the most basic costs (I., II., IV., VI.). No guide or methodological aid has been compiled for any of the cost items to provide support for evaluation and comparison within countries and internationally.

The need for this is highlighted by the Economic Working Group of the European Water Association (EWA), which is focusing in detail on the economic issues of the development and maintenance of water utility infrastructure, forming the basis for water supply and water management. (Kovács, 2020)

A research and seminar focusing on the water utility asset management of European countries found, based on the answers of nearly 100 experts from more than 20 countries, that 85% majority was of the opinion that "transparency within and among EU member states and comparability of data would be improved by a shared (EU) cost recovery guidance. (Kovács, 2020)

The value of water, as a natural resource (to start at the beginning of the logical sequence, with the currently lowest item, item IV, of the four most basic cost items) is reflected in the water resource fee in Hungary. The amount of the basic fee, pursuant to act LVII. of 1995 on water management currently in force and the relevant regulations (Ministry of Interior, 2016), is HUF 4.50/ m^3. Various consumers are liable to pay a portion of the basic fee calculated using different (increasing, decreasing) multipliers, depending on the purpose of usage (industrial consumption, agricultural irrigation, fishing, drinking water supply, etc.) and on the source of water to be used (surface water, ground water, etc.).

The value thus received results, depending on the purpose and volume of usage, and on the added value represented in the product, is a varying, typically negligible degree of motivation for using resources sparingly. In the case of urban water consumption (drinking water supply), it represents somewhere in the order of 1% of the service tariff and it is thus featured as a variable cost element subject to the volume sold. In view of the negligible value, this in itself does not result in an incentive either for preventing, avoiding water losses or for reducing consumption.

At the same time, there are extreme differences in the price per m^3 of drinking water, the national average being HUF 365.-/ m^3 gross, but there are settlements where 1 m^3 of public utility drinking water costs more than HUF 3,500, with the other extreme at a mere HUF 85.-. The wastewater tariff in Hungary is HUF 430.-/ m^3 (MEKH, 2019c) on average.

The above extremes go back to the earlier system of price regulation, when the municipalities of the individual settlements exercised price setting authority and as a result of the varying production and service cost levels in these settlements, thousands of different tariffs are still in force.

The differences in tariffs still prevail, in spite of the substantial integration among public utility service providers in recent years (since 2010, the number of service providers declined from 400 to 40), i.e., the same service provider offers services to the settlement it supplies against substantially different fees.

Such differentiation has survived even though the water utilities legislation in force has assigned price setting authority to the relevant ministry, upon supervision by the HEA. A tariff reform in substance, has not yet been implemented, though, following the tariff freeze in 2012 and the tariff reduction across the board in 2013.

It is safe to say that, on a European scale, as well, the resource cost of the use of water resources represents in the range of 1% of the tariffs, even in countries with scarce water resources. (EurEau, 2017b)

The treatment and interpretation of the costs of environmental stress (VI.) vary from country to country. In Holland, for instance, the total cost of wastewater treatment falls in this category, whereas in Hungary the costs of environmental stress are regulated by act LXXXIX of 2003 on environmental stress charges. The mission of the regulation is "*Protection of the environment and nature, mitigation of its load, providing an incentive to the users of the environment to engage in activities to save the environment and nature, as well as to secure budgetary funding for the protection of the environment and nature"* (Parliament of Hungary, 2003). The basis for the regulation is a fee payable as a tax, depending on the volume of emissions. The fee, according to the appropriations of the Hungarian Central Government diminished in the past 4 years, and had an appropriation value of HUF 4.9 billion for 2020. (KSH, 2020) Although no statistical data are available on its use, this special type of tax can cover only in part the funding needs for environmental and nature protection.

Regarding cost types I and II, in its 2016 manifesto, EWA confirms that although according to § 9. of the WFD, full cost recovery should be enforced, in most cost calculations the actual magnitude of the replacement costs of water utility infrastructure at the end of its lifecycle remains hidden. (EWA, 2016) Consequently, financing cost indicators and the reports of utility service providers are based on wrong information. The lack of information regarding actual cost data undermines the development of appropriate financing strategies and tariff systems. In most EU member states, although service charges cover the cost of day-to-day operation (I.), they do not cover the renewal of infrastructure approaching the end of its useful life (II.). Reliable and transparent information is needed to allow the consideration of affordability and solidarity criteria and to secure financing for the necessary costs using other sources.

The analysis of the profit and loss accounts based on the cost of sales method of domestic service providers accounting for more than two thirds of the sector, has revealed that on average, over the past five years, the ratio of fixed costs irrespective of the volumes served within the total amount of expenditures represented 88%, with a spread of one percentage point. (KPMG, 2015) At the same time, in Hungary, as well as in the countries of the EU, the split tariff structure, consisting of a fixed part (not linked to consumption) and a part proportionate to the actual consumption, is only partly present, and to a small extent only, with a ratio that is not aligned with reality (Kovács, 2020). This tariff structure suggests and reinforces the idea that by reducing consumption and using resource sparingly, costs can be reduced. However, as is seen from what we have concluded about the cost of water, as a natural resource, this is only true to a minimal extent at the level of the service provider and of society. Tariffs proportionate to consumption, excluding infrastructure costs generate the wrong answers at the level of the individual and lead to the wrong decisions at the level of society.

It is a universally accepted fact that developing and sustaining the infrastructure needed to ensure the availability of the service form part of the fixed costs. In light of the fact that at the time of the analyses made by KPMG, the maintenance cost of the infrastructure was reflected in the costs in Hungary to an extent of less than 10%, including and enforcing them in the tariffs would mean that the ratio of fixed costs would exceed 90%.

According to the EWA survey, within the tariffs paid for services, the fixed portion linked to availability is less than 30% in nearly 90% of the European countries. At the same time, as statistical data demonstrate, the ratio of fixed costs, not linked to consumption, exceeds 80%.

(Kovács, 2020) The rate of renewal calculated from the network reconstruction ratio (km/km) does not reach the less-than-100-years value in any a single country. In half of the respondent countries this value is 100-200 years, in another one third it is over 200 years. One out of five respondents had no pertinent data.

Unfortunately, it is mostly the purchase value (in most cases, eroded by decades of inflation) of assets that is used as the basis for depreciation (61%), and only 6% use the replacement value. It is safe to say that over the past ten years, in 33% of the countries, no indexation/correction was done at all, and again, for the past ten years, 77% of the countries have not taken any steps to adjust for the long-term inflationary effect and for the revaluation of assets. The value of the assets and depreciation is either not or only marginally (less than 20%) reflected in service charges in about half of the respondents. (Kovács, 2020) All of these data underpin my earlier statement that the decision makers (specialised and pricing authorities, executives in charge at state and municipality owners), as well as the consumers/users, society at large are unaware of the actual elements of the cost structure. This also means that strategic decisions are made on the basis of misleading information in the fields of cost and asset management, as well as in terms of tariff setting.

Funding for the cost of the reconstruction of the pipeline network is provided by service tariff revenues in a mere 14% of the countries in the survey, whereas in more than half of the respondents' fees cover less than half of the renewal costs. Thus, the response given by the experts to the questions regarding the enforcement of the polluter pays and the full cost recovery concepts, unsurprisingly reveals that in more than a quarter of the countries, cost recovery is less than 50% and in nearly half it is only between 50-90%!(Kovács, 2020)

The cost of capital of the replacement and development of the infrastructure on which the service is based can be planned, according to the opinion of experts, in light of the replacement values (as opposed to the book value). 84% of the international experts share the view unanimously held by domestic experts (100%), on the significance of knowing the replacement costs is indispensable for asset management. The following chapters shed light to the availability of these data and to the framework of cost-effective asset management based on such data.

3.3 Basis and framework of utility asset management, significance of utility asset valuation, its practical application and results in the water utility sector

Before I continue elaborating on the economic aspects of the analyses, it is important to note that the planned lifetime of the infrastructure serving as the basis for water utility services is minimum 50 years, ideally 100 years or even more. This is due also to necessity, since within that period, as has been shown above, the infrastructure cannot be renewed!

In addition to functional obsolescence (wear and tear, corrosion) a number of other factors influence its efficiency, usefulness and adequacy. Such factors are the consumption/service volume changes triggered by the demographic, economic, industrial changes occurring in the service area, including the ever more stringent statutory requirements, changes to the limit values of drinking water quality, or wastewater emissions, increasingly stringent energy efficiency requirements or the emergence of cost-effective technological solutions, leading to the premature economic obsolescence of the infrastructure.

The 2016 figures of water extraction and wastewater treatment plants show a 40% capacity utilisation for water supply and 61% for the wastewater infrastructure. (REKK, 2018). In extreme cases, this value may decline from the earlier 10 million cubic metres annual consumption to as little as 200 thousand following the loss of a major industrial consumer, leaving behind the significantly increasing replacement, maintenance and trouble-shooting costs per unit of service volume. This, in addition to economic consequences, also generates further risks in terms of the supply of healthy drinking water, as is highlighted by the Challenges and Research Tasks of the Hungarian Water Research Programme issued by the MTA:

Primarily following the introduction of water tariffs, a major shift occurred in consumer habits, leading to a continuous decrease in drinking water consumption in the last 30 years (it halved to an average of about 110 l/capita/day). The change is even more significant in small rural municipalities, partly due to urbanisation, partly because of the use of private wells (daily utility consumption is a mere 60-80 l/capita). The distribution system is oversized throughout the country for the current level of water consumption and generally of deteriorated condition. The water loss resulting from the leakage from the obsolete pipeline network is considerable (20-30%).

Reconstruction of the pipelines is both a public health, as well as an economic concern because the breach of pipe integrity is one of the primary causes for the microbiological contamination of drinking water.

Decreasing consumption leads to higher stagnation time in the distribution system, which may trigger unwanted processes (deposition of inorganic substances, leaching, biofilm formation).

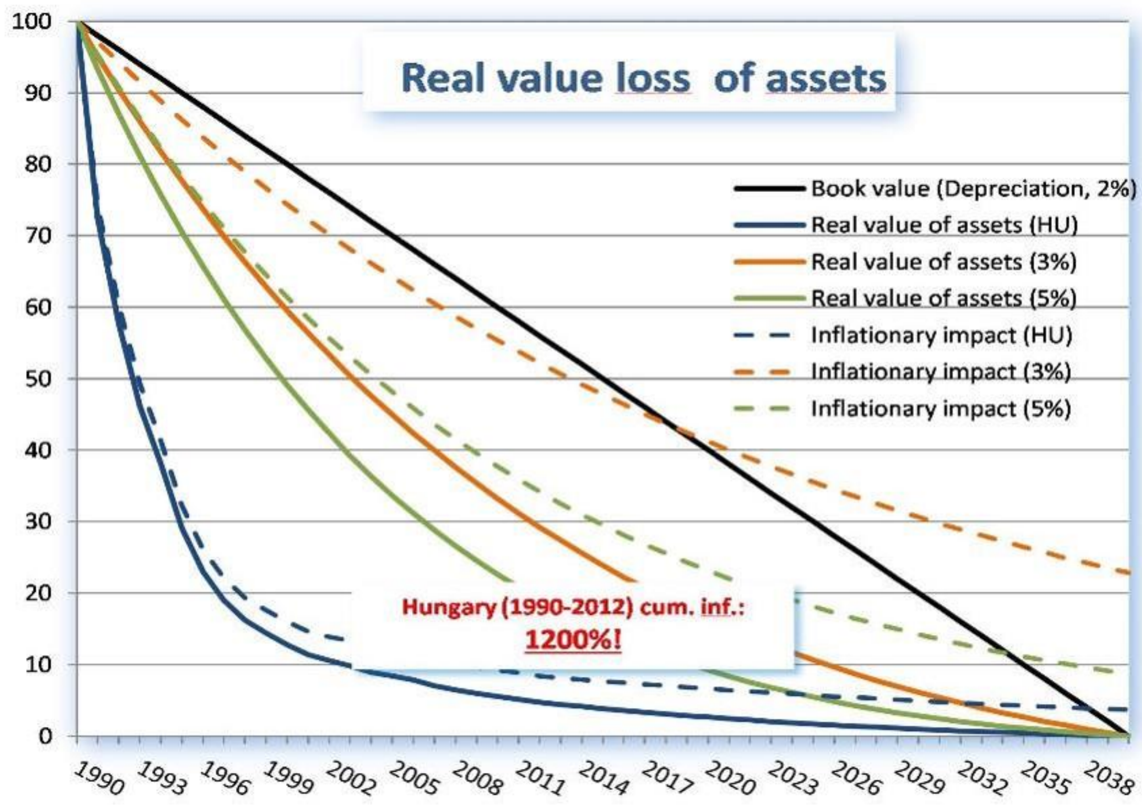
This is the so-called secondary deterioration of water, the risk of which is likely to increase in consequence of the increase in mean summer temperature caused by climate change (especially in distribution systems inside buildings more exposed to ambient temperature). Asbestos cement pipes make up more than half of the mains pipes. The health impacts of asbestos fibres released through the abrasion of asbestos cement pipes is yet to be clarified and the lifecycle and potential problems of plastic pipes used to replace asbestos are not yet known. (MTA, 2018)

The approximation of laws in the wake of Hungary's EU accession and the resulting more stringent quality requirements have led to the partial economic obsolescence of the infrastructure and the supply systems. All in all, infrastructure developments and maintenance require caution and a complex social and economic evaluation, as well as appropriately structured investment, financing and operation.

In the case of infrastructure assets planned for a 50-100 years life, lifecycle planning and maintenance and securing funding for the replacement, call for the elimination of inflationary impairment. Even a consolidated 3% annual rate of inflation will, by the 50^{th} year, devour 77% of the purchasing power of the annual depreciation (funding for replacement) (see Fig. 2.), i.e.,, in the given year, less than ¼ of the original value, or in natural terms, of the pipe section, for instance, can be replaced.

The international outlook detailed in later sections of this paper will provide examples and manifestations of this, as seen in various economic environments (thought to be most stable in the USD- and GBP-based accounting environment, among others).

During the 22 years between 1990 and 2012, the HUF was subject to a cumulative rate of inflation of 1200%, due to the double-digit inflation characteristic in some years in the 1990s. Such impairment means for utilities built in 1990 or previously, that the depreciation calculated for the value upon capitalisation (gross book value) covers only 8.3% of current replacement costs. (Author's own Fig. 2.: 2% linear depreciation, and 3% or 5% and inflationary effect in Hungary, calculated using the base year domestic inflation curve)



2. FIGURE: 2% LINEAR DEPRECIATION AND 3 AND 5% AND DOMESTIC INFLATION CURVES CALCULATED BASED ON THE REFERENCE YEAR (AUTHOR'S OWN FIGURE)

The destructive effect of inflation on the value of assets with a long lifecycle means not only the premature loss of book value and the insufficiency of the replacement funding thus generated. Disregards for the value deflecting/destroying impact of inflation also leads to substantial distortion in the analysis of and the preparation of decision-making for asset management of infrastructural assets. If the data user, supervisory authority, or decision maker acting with insufficient rigour, is satisfied by the information that *the depreciation of the assets is incorporated into the tariffs* and that *it is used for the replacement of the assets*, then the conclusions and decisions based on this information will be grossly inaccurate.

To illustrate this negative impact on valuation and analysis, it is important to highlight the shortcomings of the study commissioned by the Hungarian Infrastructure Federation, however outstanding it may be in its objectives and stop-gap in terms of its hoped-for outcome. The paper entitled "Measurement of the performance within the national economy of domestic infrastructure sectors, development and application of a system of indicators" (REKK, 2018), although significant, but precisely because it fails to consider with the appropriate weight to above inflationary effects, it can be misunderstood and if applied, may result in misleading conclusions and recommendations.

The paper makes the right observation in its sectoral summary on the status of the water utility infrastructure and its welfare performance, when stating that "***indicators of the status of water utility infrastructure and of service quality largely show that assets become obsolete, their productivity is deteriorating and the number of defects and the ratio of network losses are on the increase. The increase in the ratio of problem samples taken from drinking water and from wastewater treated and released into nature is of surprising magnitude.*** *Based on the data shown,* ***the main reason*** *for the negative tendencies* ***is that the situation characterised by a lack of funding sources does not allow for refurbishments and maintenances in the sector"***. At the same time, it suggests that the status of the assets within the water utility sector and within that, the renewal rate of the assets (investment/gross assets) is 1.3% and 1.5% in 2014 and 2015 respectively. Without investigating the very nature of investments and gross assets, these values lead to the superficial conclusion that assets are renewed every 77-66-year cycle and that the trend over time is positive.

Such interpretation calls for a twofold clarification:

- On the one hand, according to the figure of the Study illustrating the changes in the assets of the water utility sector, "investment" is the sum of the "New investment and capacity increase" and the "Refurbishments and replacement" items, from which the value of extensive capacity increase grew threefold between 2014 and 2015, with their ratio significantly exceeding the value of Refurbishments and replacements in 2015,
- On the other hand, the value of gross assets, which, although a KSH figure, and includes certain "indexed" values, however, lags far behind (by a factor of five) the actual replacement value of assets.

Thus, the **value for the indicator adjusted** twice according to both considerations, **the renewal rate of the existing assets, characterised by the indicator "Renewals and replacements/gross assets"** is 0.97%, more precisely **0.19% for 2014, and** 0.65%, more precisely **0.13% for 2016.** From these, **the actual renewal cycle of the existing facilities is 526 and 769 years, based on capital indicators.**

Contrary to the earlier renewal cycle, the acceptable-looking 60-70 years, suggested by the original indicators, the adjusted indicators suggest a cycle of 5-700 years, obviously unacceptable at first glance. The values thus corrected **indicate a deteriorating situation both in terms of the trend, and in line with the performance and adequacy indicators of the sector**.

The asset renewal ratio (km/km) expressed in natural terms (the issue at stake being network systems, where some 80% of the value of assets is made up by linear (facilities (pipelines), would lend itself to eliminate potential (and according to the above, inherent) inaccuracies of these values and economic analyses and to serve as an outstanding means for verification. This value, however, unfortunately cannot be gleaned from the records used currently, due to the difference (inaccuracy) equal to the length of the equator, expressed in kilometres, of the KSH and HEA records of the pipeline network referred to earlier.

The REKK Study formulates outstanding recommendations for the indicators facilitating the status and efficiency tests of infrastructures, one of them being:

"In the context of the infrastructure service provider side… the ratio of the value of investments commissioned during the current year versus depreciation (replacement rate) can be a useful indicator."

For which the study makes two observations regarding the depreciation of assets:

"One of the drawbacks of this indicator is that the rate of depreciation used is subject more to the depreciation policy applied than to the actual condition of the assets."

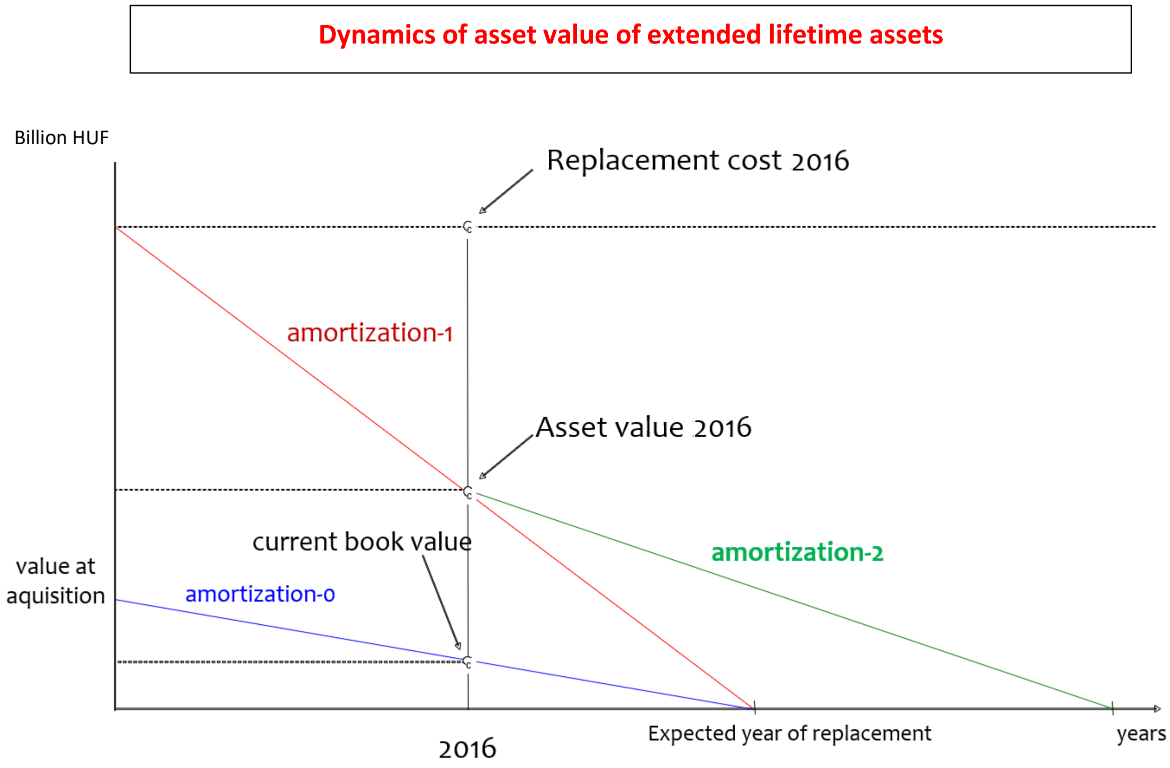
"The annual level of depreciation, however, could be determined only on the basis of corporate reports, which are not included in the present research, they can, however, be incorporated into the methodology later on."

These are observations of crucial importance in terms of this chapter and for the improvement of the effectiveness of asset management, thus the following additional observations are due:

1. To begin with, as we are aware, according to the provisions of act CCIX of 2011. on water utility supply, "Ownership rights of water utilities may only be exercised by the state or by municipalities" (Hungarian Parliament, 2011). This means that it is not the service provider but the owner, i.e., the state, or in the majority of urban areas, the municipality itself, who is responsible for the supply and for the maintenance of the infrastructure.
2. The state and local municipalities manage infrastructure assets as per the provisions of the law on central government, which means, that such assets are not featured in "corporate accounts" or in limited instances only, as will be seen when discussing the contractual forms of operation. What depreciation is used in the state and municipal accounts and how the resulting impairment/carrying value is accounted for, is not discussed in this paper. The operator of the infrastructure (mostly state- or municipally owned water utility service providers) manage and operate the infrastructure at their disposal: under operating and leasing agreements or under asset management agreements.
3. In the former case, the funding for the replacement need of assets is supposed to be provided by the lease fee, which, pursuant to the water utility act should be in the same

order of magnitude as the depreciation of assets (the calculation basis for which will be discussed in detail in the explanation of own Fig.3.), in actual fact, though, this value is completely different from the value of the assets. Lease fees are often at a zero value as a result of the earlier period when municipalities exercised price-setting authority, and fees were subject to the decisions of local tariff policies, where fee revenues are legacies that were frozen 8 years ago and later reduced, within the confines of the service provider's struggle for survival. In this operating contract scenario, real depreciation data cannot be gleaned from the accounts of either the service providers or the municipality owners. Another important stipulation of these contracts is that the replacement and renewal of the assets is the responsibility of the owner (the funding for which could be provided by the lease fee), maintenance and troubleshooting, however, are the responsibility of the operator. The operator thus sharing with the owner (who happens to be the operator's owner at the same time) the liability to maintain the service is forced to continue operating the assets ready for renewal even if the operating cost increasing year upon year of such assets exceeds by far the annuity cost of the replacements and investments thus not performed.

In the case of the asset management agreement scenario, while keeping the ownership title of the infrastructure, the state or the municipalities transfer the assets to the service providers for asset management. The assets are entered into the books of the service provider business entities and are depreciated applying a uniform rate of depreciation at both the owner and the asset manager. In this case too, the sales revenue generated through the historically low service charges and the resulting cost ceiling apply ("looks ok on paper"), which is acceptable as long as the value of assets is at a historically low level, due to inflation as described earlier. Prior to the current water utility legislation entering into force, service providers attempted to switch from the earlier lease agreements to the asset management solution. This would allow more stable planning and management of the business and would allow for the issue of troubleshooting versus renewal, a question that should be decided based on cost effectiveness considerations in the first place, to be a matter of internal discretion. However, due to the depreciation accounted for in the books of the company and shown in the profit and loss statement as a cost item, increased through the re-evaluation of the assets, operators tend to return to the lease agreement scheme, which allows for a laxer accounting of the assets.



3. FIGURE: DYNAMICS OF ASSET VALUE OF EXTENDED LIFETIME (INFRASTRUCTURAL) ASSETS (AUTHOR'S OWN FIGURE)

Figure 3. (own source) illustrates the dynamics of the change in value using the example of an asset (e.g. pipe section) with a planned/expected lifetime of about 50 years, in the middle of its lifecycle. The values are shown from capitalisation (1987) until the likely date of replacement and beyond, incorporating a valuation intended to provide for value adjustment, funding for replacement and sustainability.

It is clear that

- The replacement value as at 2012 is approximately 10-times the value upon capitalisation
- The annual depreciation resulting from "Depreciation0" (ÉCS0) based on the capitalisation value is negligible on the flat curve,
- Even if the area below ÉCS0 was available in a cumulative fashion, it would still not provide funding for the value of future replacement,
- The replacement value (the revalued Asset value) adjusted by the obsolescence (50%) of the asset at the middle of its lifecycle is half of the 2012 replacement value,

- Of the 2012 asset value, ÉCS1 running into the expected year of the replacement would be suitable to provide for at least half of the replacement funding needs in the 2nd half of the lifecycle,
- In the case of an asset management agreement, the assets shown in the books of the municipality and handed over to the service provider for asset management and taken over by the service provider as used assets, are thus “revived” in the business entity and continue generating funding for the replacement with ÉCS2, projected to the value upon handover (i.e., based on the value adjusted by the obsolescence).
- And although replacement will not be covered using ÉCS2 either (neither in 2027, when it would be due, because of the functional obsolescence, nor even in 2062, by which time the assets are “written off to 0” using the write-off rates applied to the used assets “taken over”), the owner, the service provider, and not less significantly the consumer and Society will get closer to sustaining the current value, at least.

Asset valuation, more precisely, the indexation of extended lifetime (including infrastructure) assets to eliminate inflationary effects is of great significance. This is especially true when and where the funding for the development and maintenance of the infrastructure on which the services are based, can and have to be provided through the depreciation incorporated into service charges. It is indexed depreciation that can provide, on the one hand, for the – to the extent possible - balanced and equitable distribution between generations of development and maintenance costs (vertical solidarity). Indexation is one method of value adjustment, the other is the periodical revaluation based on replacement costs and on the extent of obsolescence. Such continuous or recurring value adjustment allows for the financing of the replacement of assets using funds not subject to corporate profit tax, as well as the enforcement of the polluter pays and the full cost recovery principles. This can also foster responsible and sustainable consumer behaviour, understanding the true value of the service provided using the assets and based on this, the professional valuation of the decision scenarios regarding the development and maintenance of the service. It is following the well-founded preparation of the related decisions that subsidies of the tariff management can be considered where necessary and justified based on social solidarity considerations (horizontal solidarity).

The findings of the European survey referred to in the previous chapter show that in 77% of the countries, no steps have been taken for more than ten years to make adjustments for the long-term inflationary effect, to revalue the assets. In Act CCIX. of 2011. on water utility service (Parliament of Hungary, 2011), the Hungarian water utility regulation, in a forward looking way, made it obligatory for all entities responsible for the supply (the owners of the infrastructure: the state and the local municipalities) to carry out a comprehensive, full and itemised stock-taking and revaluation of water utility assets.

The purpose of this is to eliminate the impairment effect of the considerable (more than 1,300% between 1990 and today) cumulative inflation to which the cost/capitalisation values of the assets (objects) built at various times over the past decades (partly over 100 years ago). Additionally, the aim and necessary task was to develop a uniform asset inventory (see the differences in the official sectoral asset records, the length of the equator mentioned earlier) and to define the economic and functional obsolescence of the assets. Asset valuation forms the basis for the so-called rolling development planning (GFT), which supports cost effectiveness, as well as of the tariff setting, which provides the basis for asset maintenance and upkeep.

The method of implementation of the asset valuation is defined in the decree of the Ministry of Development (NFM) No. 24/2013. (V. 29.) on the rules of asset valuation of water utilities and on the disclosure requirements for water utility service providers (NFM, 2013a). The method of implementation of water utility asset valuation is shown in Annex I.

Depending on the tax and price setting (administrative price) regulatory environment, the lack of indexation of the depreciation (ÉCS) in the annual profit and loss statement means that the depreciation reducing the corporate tax base (see ÉCS0 in Fig. 3.) does not provide funding for the replacement needs manifest at present value. Consequently, in the event that the owner of the assets cannot secure funding and it should still be covered from the tariffs, it can (could) only be done using the after-tax profit of the company. This was the case at multiple operators during the period before the water utility legislation entered into force (when profits were still generated). Elsewhere, where attempts were made to avoid the burden of the corporate profit tax (as it is inequitable in terms of the purpose of its use and wrong in principle), such renewal investments were accounted for as maintenance cost, out of necessity.

However, as becomes clear from the study commissioned by MAVÍZ, ***in 2017, 24 out of the 41 companies reviewed, were loss-making.*** (SZÁZADVÉG, 2018) Thus, on the one hand, clearly, there is no after-tax profit generated that can be used freely to finance replacement renewals, or even the necessary maintenance works. At the same time, further sections of the study reveal: *The need for the replacement of pipeline is underscored by the increasingly frequent defects, as well. The* ***number of defects encountered on the drinking water network*** *since 2012* ***increased more than twofold,*** *whereas the* ***increase on the wastewater network was 41 per cent.*** (SZÁZADVÉG, 2018)

As can be seen from the pace of water utility developments on the one hand and from the replacement value of the total water utility assets referred to earlier, on the other, **the annual backlog in replacement for half of the replacement value of some HUF 10 thousand billion still accounts for HUF 100 billion.** If at least the ÉCS0 funding impaired through inflation was generated in the tariffs, the sector and the national economy would still suffer an impairment of at least HUF 100 billion of real value at an annual level.

This is the amount shown in the study commissioned by MAVÍZ referred to earlier: *Based on the rolling development plan approved by HEA in 2017, the reconstruction needs of water utility systems in the next 15 years amount to HUF 103 billion on average, annually. The development funding included in the current tariffs, however, do not cover renewal and replacement costs, i.e., there is no significant reconstruction undertaken on the network at the moment!* (SZÁZADVÉG, 2018)

But "Are we still falling?" as the authors of the study published in the special edition of VEZETÉSTUDOMÁNY / BUDAPEST MANAGEMENT REVIEW L. ÉVF. 2019 (Kis and Ungvári, 2019) rightly ask.

On Act CCIX of 2011 on water utility services (hereinafter: VKSZTV), as the basis for the sectoral reform, it notes that *"the stated purpose of the new regulation was to bring order to the operating relations of the sector, to put the service on a sustainable track and to enforce the interests of the consumers, all of which "through regulation in compliance with the requirements of objective, transparent and equal treatment". The legislation aimed at ensuring high-standard, sustainable and affordable water utility services across the board.*

In other words, the regulator set the objective to standardise service level in such a way that burdens are distributed among the various actors of society in a way more equal than before (affordability) and more equal among the generations (sustainability). To meet these goals, a decidedly progressive set of reforms was codified, with the following key elements: • establishment of a central water utility regulatory authority, • system of operating licences based on uniform requirements, • proper professional supervision of the operation of water utilities • sectorial integration implemented through a multi-phase minimum size requirement, • requirement to draw up and have official approval for 15-year rolling development plans, • regulation of ownership issues, • tariff-setting based on justified costs and ensuring long-term economic sustainability. (Kis and Ungvári, 2019)

In evaluating the fulfilment of the positive goals set in what was a globally unique sectorial reform package adopted 9 years ago, my summary observation is that the goals were met, apart from the last item on tariff-setting based on justified costs and ensuring long-term economic sustainability. The authority is established, the licencing system is in place, the supervision exists, integration has been achieved, the GFTs have been approved, ownership issues were regulated. It is just that, **as the studies referred to above also show, neither long-term sustainability, nor tariff-setting based on justified costs or social solidarity (consolidation of the nearly 10,000 service tariffs of considerable variation and extreme values) have been achieved.**

The study enumerates changes in substance in the way the sector functions and illustrates through some examples the positive impacts of the reforms through integration. When it comes to the last item, though, observations are all made in the conditional.

Efficiency improvement in the sector stemming from integration is also important because it can facilitate a more equal redistribution of the burdens. Efficiency improvement releases funds and if these funds can be used to reduce the highest tariffs, this means that the variation among the tariffs is reduced, whereas the increase in the funding for the reconstruction of assets promotes a more equal distribution of burdens among the generations. (Kis and Ungvári, 2019)

The fundamental reason for this might be, as the study analysing the current situation of domestic water utility service points out, that: *While in the natural gas and electricity sectors the cut in public utility costs has forced the actors to increase their internal efficiency, the water utility sector had only minimal internal reserves. The cumulative effect of this over the past 5 years amounted to HUF 82.3 billion. By today, water utility service providers have reached the upper limit of their scope for movement in terms of their efficiency, thus currently there is no more reserve available in the system.* (SZÁZADVÉG, 2018)

This conclusion is all the more justified and correct, since in the energy sector, the cost of generating and procurement of the object of the service (gas, electricity, heat) is linked to world market prices and is likely to decline through the increasing use of renewable energy sources and technological development. At the same time, in water utility services, both the depletion and contamination of water reserves, as referred to earlier and the increasingly stringent limit values for drinking water quality and wastewater discharge lead to increasing production and placement costs.

The study measuring and analysing the effects of water utility integration in Hungary and the expectations regarding future improvement in cost effectiveness and summarising 2016 survey data, also anticipated the above limitations in the improvement in cost effectiveness. (Kovács, 2019) The study reviewed a number of areas for efficiency improvement in operation and cost management (technical-engineering, human resources, procurement structure, economies of scale, etc.) and based on the analysis of the response of experts (top managers of service providers), it concluded that a 3-5% efficiency improvement was experienced by the majority of the respondents, as the cumulative effect of the integration. At the same time, following one-off stranded costs, a moderate improvement is expected for the future. During the data collection, the survey excluded taxes and institutional contributions, as well as the effects of cuts in service charges, the negative impacts of which on the business, especially on the management of assets and instruments is revealed by the studies completed since.

The authors of the study “Are we still falling?” make a forward-looking proposal, according to which *a next logical step could be the development of a tariff system that shows greater solidarity than the current one. There are numerous foreign examples for the standardisation of the tariffs of a service area or even of the entire country (e.g. Audit Scotland, 2005).*

At the same time, it also notes that *in Hungary, even considering the possibility of a shift towards a tariff structure of greater solidarity in the geographical sense is not on the agenda, since a large portion of water utility service providers face major economic challenges, resolving which takes priority over long-term planning.*

A more in-depth and detailed analysis of the Scottish example, with uniform nationwide tariffs, leads to the issue of integration of asset management and the inherent opportunities, which go way beyond tariff management and the integration of service areas!

In Scotland, Scottish Water, a public utility service provider established in 2002, offers water supply (2.4 billion litres - 2.4 million m^3 daily) and wastewater sewerage and treatment (1 billion litres – 1 million m^3) services on the territory of the entire country, to 5 million people in 2.2 million households (i.e., about half of the population of Hungary) and 133 thousand businesses with a legal entity. The book value of the Scottish water utilities (46,787 km water pipeline and 48,288 km sewerage network, 360 water treatment plant and 1,807 wastewater treatment plants) is GBP 2.8 billion. At the same time, the total replacement value of these assets is estimated at GBP 28.2 billion. (Auditor General for Scotland, 2005) The HUF equivalent of the estimated replacement value is about HUF 11 thousand billion, which is in the range of the estimated Hungarian replacement value, substantiated in part by asset valuations. More than 50% of the approximately GBP 1 billion (approximately HUF 385 billion) annual sales revenue is used to finance replacement and development investments, which corresponds to nearly 2% of the estimated replacement value of assets annually, as opposed to more than 20% of the book value. (Scottish Water, 2019) Although the inflationary exposure and trajectory of the GBP, the Scottish currency are not part of the subject matter of this paper, the 10-fold difference between the book value and the estimated replacement value is thought provoking in any event, even if the book values are depreciated by normal wear and tear and obsolescence in addition to inflation.

The fact that this can be done **as the single service provider in the country, at a uniform tariff**, is largely explained by the fact that **full solidarity in the tariff management is allowed by the nationwide rollout of the service** and the social consensus, which disregards how much water services and infrastructure development cost in the different parts of the country. The average charge for household water and wastewater services combined amounts to GBP 369/household/year (HUF 142 thousand/year/household) in Scotland, i.e., nearly GBP 1 (HUF 385) per household per day, which means that Scottish water and sewerage charges remain below those in England and Wales (ScottisWater, 2019)

The assets are owned by and kept in the books of the service provider. As a result, whether to spend on operation, i.e.,, maintenance and troubleshooting versus renewal and development of obsolete assets, is at the sole discretion and competence of the owner, thus cost effectiveness considerations can apply more!!! What still allows uniform tariff management is the fact that utilities and basic infrastructure of all settlements are in the same ownership (that of the service provider), and thus the **asset management, development and maintenance by urban settlement and accounting related to replacement, required separately by settlement**, characteristic for Hungary today, **does not preclude the possibility for the service provider to compensate among settlements.**

Pursuant to the provisions of VKSZTV, "Water utilities can only be in the ownership of the state or local municipalities" and at the same time, the owner, i.e., the state, or in the majority of urban settlements, the local municipality itself is responsible for the supply as well as for the maintenance of the infrastructure.

Due, among other factors, to the responsibility to supply and to the fact that ownership is linked to municipalities, two important principles of the water utilities legislation in force, the principles of regionalism and solidarity, can apply to a limited extent only, despite the fact that service charges are higher precisely in settlements with a smaller number of inhabitants, where income levels tend to be lower, as well.

This is duly illustrated by the "ratio of the public utility pipeline tax and the sales revenue from core activities", shown in the study presenting the current status of water utility services in Hungary. In the case of rural suppliers serving less privileged small settlements, this value may even be above 10% as a proportion of the sales revenues from the core service activity, whereas in the case of suppliers serving towns and cities, the figure may show a specific utility tax burden of less than 1% even. (SZÁZADVÉG, 2018) In view of the fact that the "public utility pipeline tax" is a tax levied on the basis of the length of the pipeline, the basis for the service, the above index expressed in %, provides a good indication of the ratio of pipeline lengths per unit of service (consumer, property connection, which represents a 5-10-fold difference among the various service providers. Pro rating is appropriate even if the different charges of the individual service providers and the differences in consumption volume per consumption unit are taken into account, as these, offsetting each other result in typically lower tariffs in larger urban settlements, with slightly higher consumption values.

The above circumstances might explain the systems at work in the background, resulting in the extreme differences in the tariffs in Hungary, fail, however, to provide guidance for the objective substantiation.

Another factor, which hinders the enforcement of the principle of regionalism and solidarity is that local municipalities discharge their duty to supply by concluding either asset management or lease-operating agreements for the operation of the infrastructure they own, "*and the revenues thus generated are managed separately,* *and can only be used to finance water utility developments – including servicing the debt used for water utility development".* (Parliament of Hungary, 2011)

Pursuant to the above, and also in accordance with the basic principle banning cross financing, also stipulated in the same legislation, the usage fees of the various assets of the individual urban settlements, as well as the development funds generated by the depreciation of the assets can be spent exclusively on the public utilities of the given urban settlement. As will be revealed by the findings of the research, there are serious problems also with the size of the funds thus generated and the distribution in time of the expenditures needed and major differences among the individual urban settlement groups.

By international comparison, one might conclude, that the 11% ratio of the service charges in 2010, for replacement and development (depreciation, asset utilisation fees) was considerably below the 45% or 69% characteristic for Germany and Switzerland, respectively. (Kovács, 2010). What's more, this ratio has further deteriorated since the tariff freeze and –reduction and does not cover even 10% of total replacement needs.

The following remark with bearing on my current topic, of a study recently published among the series of water-related OECD papers, summarising and analysing the challenges faced by the water supply, wastewater discharge and treatment and flood protection financing in EU member states should be highlighted:

"*The failure rate of water pipeline networks and the ratio of network losses have not diminished substantially in member states. The situation is particularly alarming in Hungary, where network losses increased by 5% during the period 2005-2013 (as referenced by the 2017 report of the European Court of Auditors), and are currently at 26%, in Romania, where the* *increase was from 30% to currently above 40% and in Bulgaria, where such losses are steadily at 60%."*

"The lack of a realistic financing strategy is an acute problem especially in small rural settlements (and villages)." "There seems to be a serious conflict between the substantial investment needs and the technical-engineering and financing capabilities of small (especially rural) settlements. The issue of affordability is growing in small settlements."

The lack of expertise (engineering, consulting, contracting and operating) is a limiting factor for the renewal and maintenance of the existing facilities. Long-term strategic planning is a particular challenge especially for small settlements. (OECD, 2020)

In terms of the accounting of capital costs, regulations vary not just at the EU member state level, but even among territories within the Federal Republic of Germany for the way in which depreciation of the infrastructure can be reflected in the tariffs. Some territories generate funding using the so-called historic model reduced by the inflationary effects upon capitalisation (Historischer Anschaffungs- und Herstellungskosten), others use the present replacement value (Wiederbeschaffungswert) (Arbeitsgruppe Datenbank und Kostenkalkulation der Verbände BDEW und VKU, 2012a). In either scenario, the German regulation puts great emphasis on sustaining the purchasing power of the depreciation and of the value of the existing assets.

In the United Kingdom, the privatisation was completed in 1989. Prior to that, basically the entire population was connected to the water mains, thus private investors "only" had the task of sustaining and replacing existing systems (Hall and Lobina, 2012), which was then contradicted by the results of the privatisation. To facilitate privatisation, water utility development loans accumulated until then were fully written off (impaired), subsequent to which only 4% of the assets invested remained in the books, thus the pre-1989 capital costs are not reflected in the tariffs. (Hollos, 2003) This is why privatised public utility service providers have a substantial backlog in replacing pipeline networks. The total length of sewerage networks in critical state is 73,537 km, of which the length of pipelines renewed or replaced during the 10 years following privatisation, between 1990-1999 is a mere 1,948 km. Thus, the resulting expected life of the pipelines is 486 years on average. (Hollos, 2003)

The American Water Works Association (AWWA) of the United States conducted a comprehensive survey on the renewal needs of water supply pipeline networks. The survey heralds the beginning of a new era: *the period of infrastructure renewal!*

The inevitable renewal of much of the more than one-million-mile network is forecast, with total investment needs for the next 25 years projected in excess of a thousand billion USD, although no details at the level of the individual settlements or service providers are provided. At the consumer level, a substantial added cost contribution, on average 3-times the current level is identified, highlighting the severely deprived state of small settlements, where the annual added burden is forecast at USD 500 per household annually, with the figure even in the case of larger urban settlements exceeding USD 100 annually.

In the event of potential further delays in investments, in consideration of the safety of supply and service quality, and of the increasing maintenance and troubleshooting costs, an increase in costs and burdens, inevitable also in this case, is predicted.

Today's people are reminded that the renewal of the infrastructure built, financed and bequeathed by our predecessors is unavoidable and although as a suggestion only, it stresses that compared to the previous decades, the individual service providers and urban settlements will be subjected to unprecedented burdens of varying magnitudes. (American Water Works Association, 2010)

In the market-oriented US, there is only limited room for solidarity, as has been pointed out by the study prepared by the consumer protection organisation Food&Water Watch in 2010. Water infrastructure developments over the past decades have been shifted from federal level to the states and from there to urban settlements and ultimately to the level of the consumers. (Watch, 2010)

In Switzerland, water utility services operate the same way as their watches: accurately, predictably and cost effectively in the long run. The average replacement cost ratio within the tariffs is nearly 70%. Although we may not initially consider asking how much the supply of one m^3 of water costs, believing that it surely is a lot more than what we pay, we might find some surprising data. At a recently held international conference, where the president of the Swiss water utility federation was also present (as the speaker following my presentation), I brought up the German, Swiss and Hungarian replacement cost ratio figures referred to earlier. In the crossfire of a Q and A session, it was revealed that the charge for 1 m^3 of water is the same at the Luzern water utility supplier he manages as what we pay in Budapest, even though, or maybe precisely because 79% of the total charge is spent on renewals and on the upgrading and repairs leading to efficiency improvement of equipment and process control systems.

Notwithstanding, a water management study on the Challenges and Possible Action, prepared by the Swiss Federal Environmental Authority as an outlook to 2025, (Ernst Basler und Partner AG, 2007), warns against the increased challenges in the field of communal water management. It refers to diminishing water resources and the supporting system developments on the one hand and to the increasing pollution of waters and ever more stringent quality requirements, as well as the ever more pressing need for renewal of water supply and wastewater sewerage systems.

Surprisingly, in light of the largely fragmented Swiss municipal system, the study anticipates regional or even canton-level cooperation and consolidation in terms of both financing and professional know-how transfer on a general scale and especially for smaller urban settlements.

In Ireland, water supply is the responsibility of the national water supply entity and consumers do not pay for normal household water consumption. Costs are covered by the central budget, using other central budget tax revenues. According to 2011 data, per capita water consumption is the highest in Ireland, amounting to 146.2 m^3/year, whereas in Belgium it is a mere 26.5 m^3/year and about 35 m^3/year in Hungary. According to the calculations of Irish Water, EUR 5.5 billion would need to be spent on the water supply infrastructure to ensure its appropriate condition. Actual data on water consumption only became known after 2014, with the introduction of metering and temporary invoicing for water charges. According to a 2014 figure, Ireland had 973 communal waterworks and 22% of consumers had private or small community wells and 29% had the septic tank “solution”. The latter group are self-sufficient but are the recipients of planned state subsidy. Obsolete networks, frequently burst pipes, inadequate water quality (infections, cases of lead poisoning, supply of water to be consumed only after boiling), network losses of nearly 50% have led to considerable discontent among the consumer population. Following the change in government in 2016, the new Minister for the Environment and Climate and Communications set up a group of international experts for the termination of water charges and to fix the severely ailing supply and regulatory system. (Duffy, 2016b)

The 2016 Report on the Wastewater Sector (ASSMANN, 2016), of the Austrian Water and Waste Management Federation (ÖWAV) reports that 95% of Austria’s population is provided with sanitation services and that there is full wastewater treatment. The public sewerage network with a total length of 91.000 kms and the 1,840 communal and some 14,000 local, small wastewater treatment systems (<50 LE) represent a value of EUR 44,4 billion (HUF 15,400 billion), of which exactly 75% are the pipelines and provide excellent service. State subsidy is an important element of financing, but a targeted tariff increasing programme was implemented in recent years, to gradually shift to cost recovery from the tariffs, especially with regard to the reconstruction needs amounting to hundreds of millions of EUR annually (in excess of HUF 100 billion/year just for sewerage services!). Detailed and itemised data are available for the technical condition of both sewerage networks and wastewater treatment plants. Since 2006, the Austrian Ministry for Agriculture, Forestry, Environment and Water Management has been offering subsidies for the establishment of the so-called Performance information system and data bank (Leistungsinformationssysteme (LIS)) and for the assessment of reconstruction needs.

Local municipalities have the discretion over supply and price setting, and since 2012, these have been responsible to calculate and publish the so-called sample household wastewater cost chart. Once these itemised technical and economic data are available, the technical and cost data are processed by groups based on the size of the settlements and the results are published among the widest range of consumers.

Based on their data processing and analyses, costs/service charges (see fig. 5.) show a marked, 5-6-fold difference at the expense of small urban settlements, which may be closely related to the population density and to the per capita sewerage length (see Fig. 4.)

As is shown in Figures 4 and 5, there is tangible increase in the variation range in the case of smaller settlements, which, among other factors, highlights the importance of cost effectiveness analysis upon selecting possible supply scenarios. (ASSMANN, 2016a)

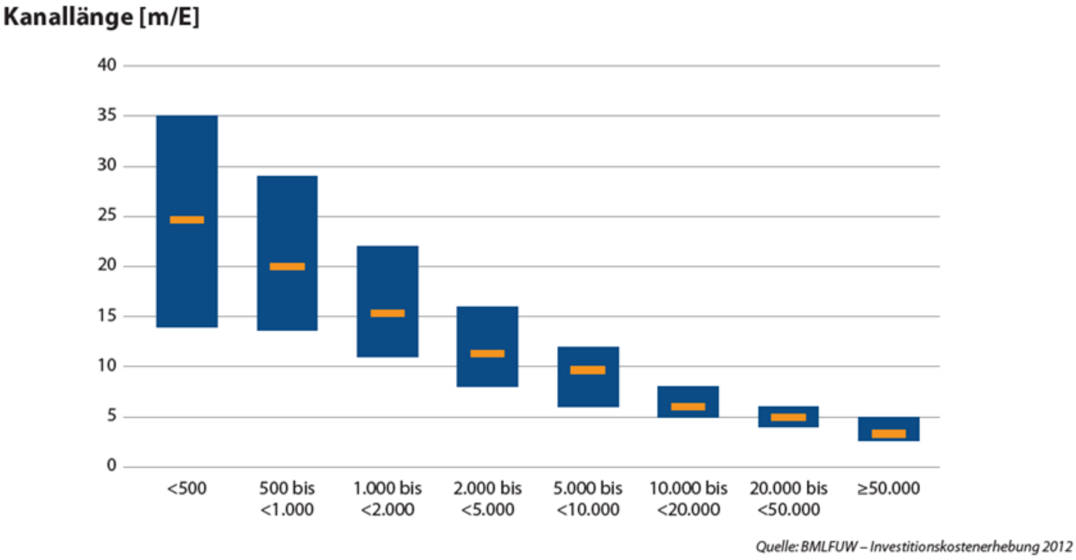
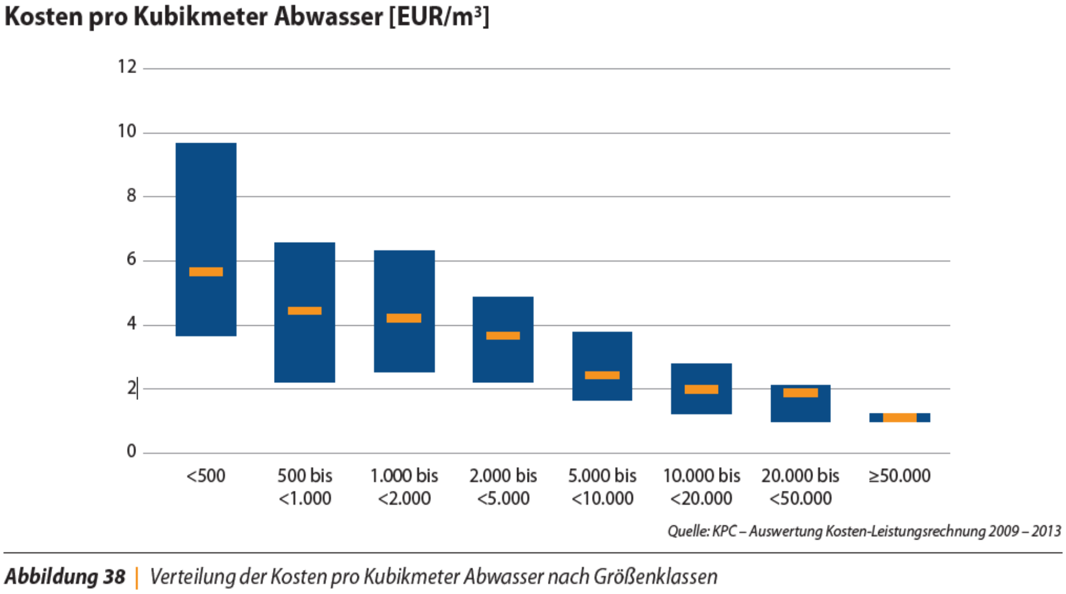


Abbildung 11 | *Durchschnittliche Schmutz- und Mischwasserkanallänge je Einwohner nach Größenklassen*

4. FIGURE: DATA PROCESSING AND ANALYSIS OF SIZE OF URBAN SETTLEMENT AND PER CAPITA SEWERAGE LENGTH – AUSTRIA (ASSMANN, 2016B)



5. FIGURE: COST ANALYSIS OF 1 M3 OF WASTEWATER SERVICE BY URBAN SETTLEMENT SIZE – AUSTRIA (ASSMANN, 2016B)

The Austrian data and the relations adequately illustrate that as the size of the urban settlement diminishes, the average length of per capita sewerage pipe and its variation range increases (Fig. 4.) The charge and variation range for wastewater discharge and treatment per m^3 follows almost entirely the same trend. These values largely match the figures measured and established in asset valuations in Hungary, i.e., show 5-6-fold differences at the ends of the scale. It is worth noting that according to the Austrian practice, the value adjustment, replacement funding and cost planning function of the valuation is fulfilled by the value upon procurement, indexed for inflation, i.e., by the book values rather than the replacement value adjusted by obsolescence. An important additional information is that in Austria, as in the entire EUR region, the cumulative rate of inflation during the period 2000-2013 was 27%, whereas service tariffs during the same period showed a 51% nominal increase, i.e., a 24% increase in real terms. (ASSMANN, 2016a)

3.4 Practical application of the valuation of public utility assets and its results in the water utility sector

In accordance with the European Valuation Standards and its guidance notes, methodologically speaking, three different approaches and methods could be applied to valuation. These are inflationary indexation based on book value, market value assessment, and the definition of the reproduction/replacement cost of existing assets, the latter of which is based on the valuation of replacement cost adjusted by obsolescence (TEGOVA, 2016). Water utilities, which are marketable only to a limited extent (or, in the Hungarian regulatory environment not marketable at all) cannot be valuated taking the market value approach, for two reasons:

- On the one hand, in the given infrastructural environment (crisscrossing the urban settlement), because of its complexity, it cannot be compared to either other utilities of the same settlement, or similar public utilities of other settlements,
- On the other hand, since the service rendered using the assets, is subject to central price regulation, its profit generating capacity is influenced by factors other than market conditions.

  Pursuant to the regulation by degrees as introduced in Annex 1., the valuation is fundamentally done by adjusting the replacement cost by obsolescence, while in cases limited in time, indexation based on the book value can be applied.

The time limitation applied to the valuation based on indexation of book value has two reasons:

- On the one hand, inflationary trends in the sector result in increasing uncertainty as time passes, what is even more important, though, is that
- As time passes, consumption, regulatory as well as technological and energy efficiency development under way in the meantime may result in the premature economic obsolescence of the infrastructure created with fixed capacity and engineering content in the long run.

When existing facilities are valuated based on the reproduction cost, two key data have to be determined for the valuation of the replacement cost adjusted by obsolescence: the replacement cost and the level of obsolescence and the remaining useful lifetime derived from the former.

The basis for these valuations is provided by the itemised calculation of replacement values and in special cases by targeted proposals. In Hungary, more than 1000 major investment projects were realised over the past decades. The cost calculation guidelines “The specific costs of water supply, water management, sanitation and wastewater treatment” (Kovács and et al, 2009), laying the foundation for the preparation of these projects, provided invaluable support in determining replacement values.

The Development Directorate of the Ministry of the Environment and Water Management (KvVM-Fi) commissioned the development of specific cost indicators necessary to prepare and verify the cost-benefit analysis of wastewater treatment and drinking water supply projects financed through the EEOP.

The purpose of the development was to come up with a suitable engineering and economic guide or aid to be used in the preparation, verification and evaluation of the preliminary and detailed feasibility studies of drinking water supply and sewerage and wastewater treatment investments, as well in selecting sustainable solutions and in making grant decisions. For this, typical engineering contents and units of facilities had to be identified, to which then specific costs (for replacement, for the purpose of later valuations), as well as expected lifetimes, reasonable from the point of view of sustainability, operating costs and eligibility for grants had to be attributed. The database was developed under my leadership, with the involvement of a wide range of (design, contracting, manufacturing, operating, engineering and economic) experts and reinforced by institutions (MMK, MTA, MAVÍZ, HWA, BME, KvVM) coordinating and evaluating a broad social discourse of the results. It is important to note that the pipeline facilities are in many urban settlements located underneath public roads, therefore the construction and replacement of such assets involves substantial external costs (amounting to 10-30% of the investment value), due to road surface and road network renewal needs, as well as those due to traffic restrictions and other environmental stresses often disregarded in the calculations. In view of the fact that EEOP-financed projects could provide partial financing for reconstruction works, as well as for unique, tailor-made wastewater treatment solutions within the agglomeration area of a given settlement even to a limited extent, specific cost indicators applied also to the no-dig reconstruction and the engineering content of tailor-made solutions.

The Multipurpose Infrastructure Assessment Database (MIAD) software, a valuation support tool, was developed upon my initiative and under my leadership, featuring the itemised calculation of replacement values and the possibility to solicit targeted offers in special cases, in addition to integrating these specific unit cost indicators (see Fig. 6.) (Kovács and et al, 2010). While offering wide valuer and expert access, the MIAD software was used in the past decade to support the valuation and enable data processing of water utility assets in two thirds of Hungarian urban settlements.

V.3. Water distribution

3.1. Drinking water networks

3.1. Drinking water networks														
			Nominal diameter*(3)	mm	-/90	80/110	100/125	125/160	150/200	200/250	250/315	300/355	350/400	400/500
Base unit price *(1) HUF/rm	Pipe material	Projected lifecycle (year)	Annual depreciation (%)	Relevant standards	Unit price (HUF/rm)									
	Ductile Iron (min. Fn 32 kN/m)	80	1,30%	EN 545	-	22 500 – 25 500	24 000 – 26 000	28 000 - 28 500	30 500 - 31 000	34 000 - 36 500	40 500 -47 500	46 500 - 49 000	58 000 - 59 500	64 500 – 66 500
	PE SDR 11 (16 bar)	50	2,00%	EN 12201	17 000	18 000 - 20 000	19 000 – 21 000	21 000 21 500	24 000 - 25 500	28 000 - 32 500	35 500 - 41 000	43 500 - 49 000	51 500 - 60 500	63 500 - 73 500
	PE SDR 17 (10 bar)	50	2,00%	EN 12201	17 000	17 500 – 19 500	18 000 – 20 000	20 000 21 000	22 500 - 23 000	25 500 - 29 000	31 500 - 35 500	38 000 - 42 500	45 000 - 54 000	56 500 - 66 000
Excess costs*(2)	Open water keeping				3 200	3 200	3 200	3 200	3 200	3 200	3 200	3 200	3 200	3 200
	Vacuum-well drainage (single-time)				7 800	7 800	7 800	7 800	7 800	7 800	7 800	7 800	7 800	7 800
	Road-rehabilitation-half carriage way, 3.0 m wide (milling, laying down the layers, 5 cm thickness, Ac11)				8 800	8 800	8 800	8 800	8 800	8 800	8 800	8 800	8 800	8 800
	Correction factor of laying, to a depth of 1.5-2.5 m				1 700	1 700	1 800	2 100	2 300	2 700	3 400	3 500	4 300	4 600
	Cost increasing factor in the case of soil-quality class IV. to VI.				1 700	1 700	1 800	2 100	2 300	2 700	3 400	3 500	4 300	4 600

Comments:

*(1) The price shall include the following: the price of the pipe material, the costs of the breaking up of road surfaces, transport and disposal of the surfacing material, excavation, earth refilling, compacting, bedding, transportation of excess earth, landfill fees, strutting, sections, connecti equipment (hydrants at every 200 meters, valves in manholes or in valve-boxes, depending on their diameters), water-tightness testing, disinfection, rehabilitation of the road surface in a band-like manner, as well as those of geodetical surveying and documentation.

*(2) Excess costs incurring depending on pipe materials and construction works conditions.

*(3) Inner Ø for Ductile Iron pipe material / Outer Ø for PE pipe material

General starting points for the calculation of specific costs:

- Net (VAT-free) engineer prices
- The prices are applicable to tenders submitted in 2009.
- The prices cover the costs of the technical contents to be realized with 90% probability.
- The engineer prices in the tender must be justified in accordance with the civil-engineering and technical circumstances stipulated as starting points.

6. FIGURE: SPECIFIC COST INDICATOR OF EEOP-FUNDED WASTEWATER TREATMENT AND DRINKING WATER SUPPLY PROJECTS – DRINKING WATER NETWORK (KOVÁCS, 2009)

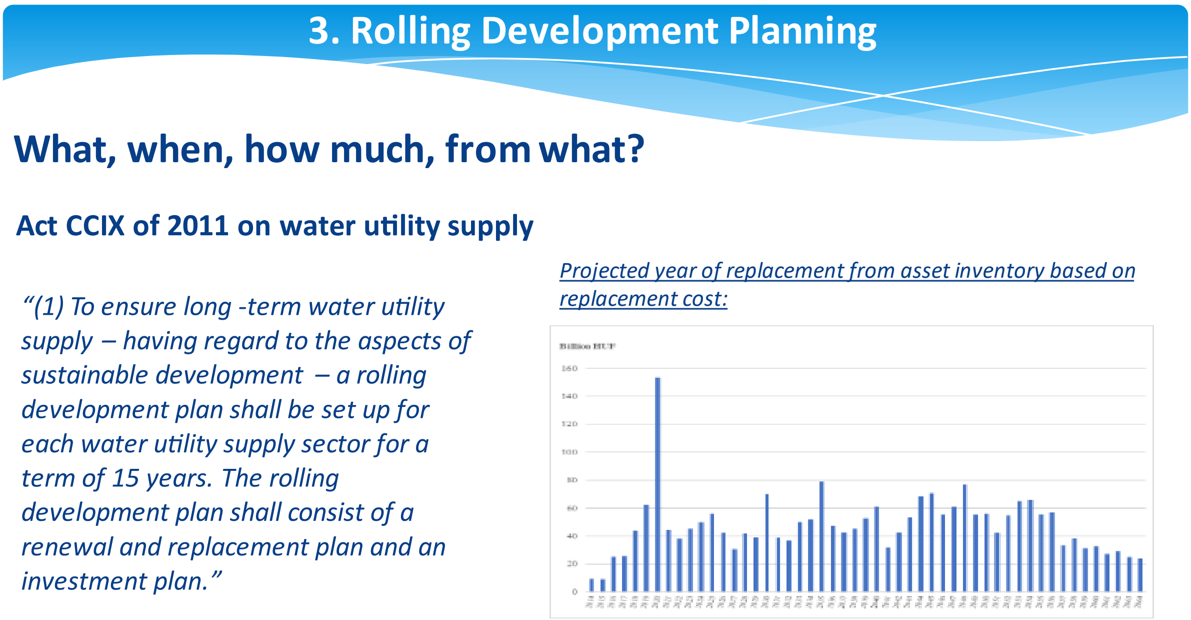
In the course of the valuations, in addition to the name of the objects and their territorial identification data, technical-engineering characteristics (diameter, material, construction depth, presence of road surface), a status survey (obsolescence, expected life), as well as economic values (replacement and asset value) were also recorded (some 20 pieces of data for each object), as per the relevant regulation.

Of tens of millions of data from millions of objects in total, replacement values for the infrastructure within the supply areas can be summarised per year, broken down by urban settlement, water and wastewater sector and within those grouped by lined (pipeline) and point-like facilities. The database thus created allows for diverse data processing and research. The replacement value data lines that can be summarised by settlement, typically provide information regarding replacement needs expressed in HUF terms and broken down by year, for the 50 years following the valuation.

The valuation pyramid for public utility assets aptly illustrates the workflow and the successive phases, ranging from recording map data, through the digitalisation of map and other data and the establishment of asset inventories and status survey and the definition of consistency indices and replacement values to data processing in support of asset management based on asset valuation:

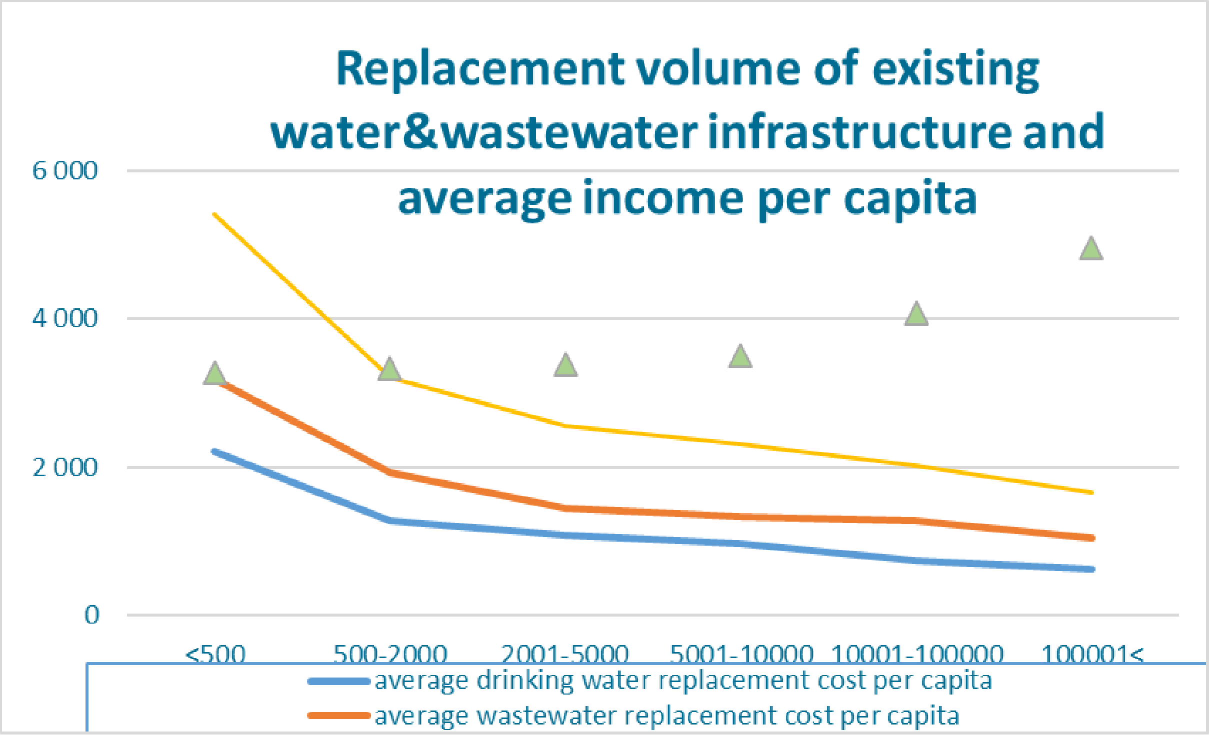
7. FIGURE: VALUATION PYRAMID FOR PUBLIC UTILITY ASSETS, DATA PROCESSING USING THE MIAD SOFTWARE (AUTHOR'S OWN FIGURE)

As asset valuations progressed, in summary of the experiences gathered along the way, although it had to be noted that *"Unfortunately, there was considerable time-lag between the adoption of the VKSZTV (31. December, 2011.), the publication of the implementing legislation* for valuation (29. May, 2013.) and the provisions** for the GFT (26. November, 2014.), thus there are substantial differences in the discovery and processing depth and quality of valuation data.* (Kovács and Füstös, 2015), this, however, did not apply to the valuations performed using the MIAD software. The structure of the MIAD software met the requirements of both the asset valuation and of the rolling development planning. In addition to meeting statutory requirements, data processing supported by the MIAD software also lays the foundation for the short-, medium- and long-term planning of the GFT (see Fig. 7.) Using the MIAD software, financial planning can be supported through easily quarriable data: (ÉCS-1; ÉCS-2), as well as the enforcement of the least cost principle (Vksztv: (1) in section of 1.§ of act CCIX of 2011.). The software environment also allows for repair and troubleshooting costs incurred during operation to be attributed to the objects featured in the database and to calculate the economic obsolescence of the object in question (i.e., a pipe section), depending on the trends in such costs, as well as on the annuity costs of replacement of the object. The methodology allowing dynamic cost calculation (DCC) of the versions without or including reconstruction, was also developed upon my initiative, with my involvement as co-chairman of the international working group. (EWA, 2011b)



8. FIGURE: LEGISLATIVE REFERENCE OF THE ROLLING DEVELOPMENT PLAN (AUTHOR'S OWN FIGURE)

Data available in the software were processed and evaluated by settlement size groups, leading to the first valuations based on actual data, as shown by the following figure:



9. FIGURE: FIRST DATA PROCESSING AVAILABLE IN THE MIAD SOFTWARE, BASED ON ACTUAL DATA BY GROUPS BASED ON SETTLEMENT SIZE (AUTHOR'S OWN FIGURE)

The basis for rendering the service is the water utility infrastructure, the cost of capital of which makes up a significant portion (50-80%) of the costs of sustainable services. Analysis of the nearly 2000 settlements shown in Fig. 9., reveals that the investment/replacement value of infrastructure per capita shows a considerable (up to 5-fold) variation among urban settlements of different sizes. At the same time, it is precisely in smaller settlements with higher specific cost values that the per capita income is lower, thus their capacity to bear costs and the enforcement of the polluter pays principle and that of full cost recovery (WFD, paragraph 9) presents major social and economic challenges for those involved. To make things even more difficult, infrastructure development and in its wake, replacement needs are not spread evenly in time. The results of the database analysis show that in smaller settlements not only the per capita replacement values are higher but their distribution over time is also extremely uneven.

3.5 Solidarity in water utility services, social engagement of inhabitants of settlements of different sizes, in the interest of sustainable water supply

Adaptation to climate change, within that to changes affecting water management, *calls for collective action in addition to individual efforts. Collective solutions can be based on solidarity.*

Solidarity has one-sided (assisting communities in need) and mutual forms (serving a common interest), exercised voluntarily or enforced by the law. (Keessen et al., 2016)

If the law is seen "as a formal tool of social changes", it must also address the issue of solidarity. For solidarity to be present, interests have to coincide and there has to be spatial proximity. In light of the fact that neither environmental effects, nor the water cycle know boundaries either in a qualitative or quantitative sense, "*international law is developing from the case law of "cohabitation" towards the "institutionalised case law of cooperation"* (Magsig, 2015)

This development is evidenced by the UN's declaration of the universal access to water and sanitation and its sustainable management, one of the Sustainable Development Goals (SDG) set by the UN in 2015, as an independent special target (UNO Assembly, 2015). *The Agenda focuses on the Sustainable Development Goals (SDG), applicable to all nations and "leaving no-one behind".* (KSH, 2018)

We are witnessing this forward looking change, when the progress made in the practical implementation of the right to water is published by the UN in its World Water Development Report in 2019 under the title "Leaving no-one behind" (UNO, 2019), "senkit sem kihagyva", as the KSH puts it in Hungarian, "Ne laisser personne pour compte" in French (Unies, 2019), "Не оставляя никого в стороне" (ООН, 2019) in Russian (ООН, 2019), and Niemanden zurücklassen (VN, 2019) in literal translation into German, **titles advocating total solidarity**.

Magsig's classic interpretation of the criteria of the development of cooperation and solidarity, referring to the coincidence of interests and spatial proximity, has resulted in but apparent and slowly unfolding solidarity, in spite of the eloquent statements, calls and programmes. The gradual depletion and contamination of cross-border shared river basins and water reserves, and the slow and according to some still debated recognition of the limits and sustaining power of our planet, and the migratory pressure triggered partly by climate crisis, partly by overpopulation, have not resulted in any major progress.

The threat of the COVID-19 pandemic unfolding these days envisages drastic changes in understanding and perceiving the needs for solidarity. The pandemic highlights the dramatically increasing significance in terms of hygiene of the access to clean and sufficient water and regular sanitation, as it affects the entire planet (creating the Magsig-type proximity) in space, and the whole of mankind (strengthening thereby the coincidence of interests), prompting immediate action in time. The internal relations are aptly illustrated by the joint publication of FAO, WOAH and WHO "On the prevention of infections and combatting antibiotic resistance, on Water, Sanitation, Hygiene and Waste management". The publication reiterates the responsibility of sectors critical for human existence and the shared responsibility and joint action among and above nations. (WHO, 2020) The publication preceded the outbreak of the COVID-19 pandemic, to which the UN issued an immediate Framework Programme, in which the primary statement is that "*We are all interconnected and need borderless solidarity."* (UNO, 2020)

One of the 6 main sectorial undertakings in the UNDS Framework Programme *was "the maintenance of continuity and quality of the water and sanitation services"*, which, of course, would be too nice to be true, since we all know this did not exist before either, as is pointed out later: *"Location matters. Crisis enlarges inequities, especially in vulnerable areas, such as refugee camps, outer districts of large cities, small rural settlements ... where social services are scarce, hand washing and hygiene can be difficult without adequate services and water ..."* (UNO, 2020).

At the same time, in the context of the global emergency caused by the Coronavirus, the webpage of UN-Water states: "*The spread of the virus is closely related to water and sanitation. Cleaning hands can reduce the transmission and help people stay healthy but today billions of people lack safe water, sanitation and handwashing due to a lack of adequate funding."* (UNWATER, 2020)

What the 3rd National Solidarity and Health Plan of the French Ministry of Solidarity and Health, issued in 2015 envisaged, actually happened and it shocked the world in more ways than one: *Our health depends on the health of the biosphere, which is directly related to biodiversity. It is essential to understand the impact of environmental changes on the dynamics of pathogen organisms and on the development of diseases. Infectious diseases are proliferating."* (MIN-SOLIDARITÉS-SANTÉ, 2015).

Readers of this paper and those informed through the above publications by international organisations of the appalling situations and worldwide inequities, and aware of the social, demographic, environmental, what is more, health disasters looming in consequence of the social inequities and affecting everyone, know that solidarity is necessary. It is probably those in need who are least aware that someone should show solidarity towards them. It has not become clear though:

How?: should we offer our water? (but it rains there too…)

How can we get it to them? Shall we bottle it and ship it to them? Or should we build a pipeline all the way there? Or build a reservoir there? Or a water and wastewater treatment plant? Or just give them money so that they can build for themselves?

Who should we demonstrate solidarity towards? The neighbour? Those living in the neighbouring settlement? Inhabitants of the neighbouring country or continent? Or maybe towards Americans living in small settlements, faced with unprecedented network renewals and threatened by tripling service charges? Towards future generations, to whom we could bequeath infrastructure in good condition? Or maybe we don't really know and it is others who should show solidarity towards us? Or should we be enjoying the benefit of water treatment plants and sewerage plants and wastewater treatment, and services financed through EU grants and state tax funds? Should we just be benefitting from the barely functioning infrastructure inherited from previous generations, with refurbishments put off at the expense of future generations? Why exactly? And if so, how much would that cost us? Or if not, how much can we save that way? And how exactly should we be showing solidarity?

The answer to these questions will allude us as long as we do not have realistic and transparent information on how much the infrastructure and its replacement, maintenance and operation cost. First, we need to find out the actual cost of cleaning and distributing to the consumers 1 litre, 1 m^3 of water and the actual cost of collecting, draining and treating wastewater. In the absence of this information, we cannot effectively consider possible alternatives of supply and cannot compare their costs with that of pipelined water supply and cannot assess the health and environmental damages and related costs caused by the lack of adequate services.….

There are some good examples, though: Scotland, for instance, with maintenance and operating costs managed through uniform tariffs for domestic consumers (in small and larger urban settlements), or Austria, where solidarity is only partially present, nevertheless they are beginning to see actual costs and their differences between supply environments in rural areas versus cities.

Thus, in addition to the cost structure of urban water supply, the knowledge of and approach to Water-Value of society at large is examined, with intergenerational vertical social engagement and solidarity on the one hand and horizontal social engagement and solidarity of those living in the individual settlements and regions on the other.

In the paper, I focus on the social engagement needed and solidarity requirements presented by the considerable differences and disparities in the water infrastructure development and replacement needs by settlement size and in the property and income relations of the inhabitants. To what extent do people living in settlements of different sizes experience the difference in the costs of water utility service and to what extent are they willing to demonstrate and do they expect social engagement and solidarity, in the interest of ensuring universally accessible and sustainable water supply?

My questions aimed at measuring solidarity attitude, were incorporated into the focus-group based research of HWA, "WATERVALUE - Water in the household, domestic perception of water supply and water treatment", a survey with a 5000-strong sample and the findings were adopted from the database thus generated. (MASZESZ, 2020b)

3.6 Hypotheses

1. The replacement costs per inhabitant, of infrastructure on which water utility services are based show significant differences in urbans settlements of different sizes, with the difference being of orders of magnitude at the extreme values, where the value in smaller settlements is a multiple of the value in larger settlements.
2. The average (spread evenly over time) cost requirements of sustaining and replacing the water utility infrastructure are considerably higher than the funding afforded in the current service environment (tariff structure). To make matters even worse, replacement needs vary greatly over time because of the age distribution and technical condition of the water utility infrastructure. For drinking water supply systems, this value is extraordinarily high for the near future (next 15 years).
3. The distribution over time of replacement needs varies by sector and settlement type, meaning that such needs are more concentrated in time, with higher outlier values in smaller settlements, and can in time become more balanced and as such better manageable in the tariffs through the consolidation of asset management among the sectors and through the regional management of municipal assets (regional consolidation of water utility systems).
4. The replacement values of the infrastructure are reflected in the service charges, which thus are significantly higher in smaller urban settlements than the service charges in cities.
5. Groups of society living in smaller and large urban settlements are aware of the significant differences in the cost of municipal water and sewerage services depending on the size of the settlement and feel the need to renew the infrastructure and on the one hand require, on the other hand are willing to provide compensation and offer solidarity and social engagement.

1. TABLE: LITERARY REFERENCES ON WHICH THE HYPOTHESES ARE BASED

HYPOTHESIS	SOURCE CITED	WORKS CITED
1	(United Nations Economic Commission for Africa, 2015)	United Nations Economic Commission for Africa (2015) *Assessing progress in Africa toward the millennium development goals*
	(Government of Hungary, 2017)	Government of Hungary (2017) *National Water Strategy*
	(American Water Works Association, 2010)	American Water Works Association (2010) *BURIED NO LONGER: Confronting America's Water Infrastructure Challenge*

HYPOTHESIS	SOURCE CITED	WORKS CITED
	(SZÁZADVÉG, 2016)	SZÁZADVÉG (2016) *ACTION PLAN On the tasks related to the proposals for the water utility sector of the Kvassay Jenő Plan 2016*
	(OECD Multi-stakeholder declaration, 2015)	OECD Multi-stakeholder declaration (2015) *OECD Principles on Water Governance*
	(OECD, 2009)	OECD (2009) *Managing Water for All an OECD perspective on pricing and financing*
	(Doshi, 2007)	Doshi, V. et A. (2007) 'Light! Water! Motion', *Strategy and Business*
	(Swilling *et al.*, 2013a)	Swilling, M. *et al.* (2013) *UNEP City-Level Decoupling Urban resource flows*
	(BM KVHÁ, 2014b)	BM KVHÁ (2014) INFORMATION *91/271/EEC Directive on National Implementation Programme*
	(Kovács, 2020)	K. Kovács (2020) 'Water utility asset management in Europe'
	(Somlyódy, 2011)	L. Somlyódy (2011) *Water management in Hungary: situation report and strategic tasks*
	(SZÁZADVÉG, 2018)	SZÁZADVÉG (2018) *THE CURRENT SITUATION OF WATER UTILITY SERVICES IN HUNGARY*
	(Kis and Ungvári, 2019)	A. Kis, and G. Ungvári (2019) 'ARE WE STILL FALLING? SUSTAINABILITY AND EQUITY IN WATER UTILITY SERVICES IN HUNGARY
	(Kovács, 2019)	K. Kovács (2019) 'WATER UTILITY INTEGRATION IN HUNGARY: IMPACTS AND FUTURE EXPECTATIONS
	(OECD, 2020)	OECD (2020) *Water sector: financing water supply, sanitation and flood protection*
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	(ASSMANN, 2016a)	ASSMANN, M. (2016) 'Branchenbild der österreichischen Abwasserwirtschaft'
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	(Kovács, 2019)	K. Kovács (2019) ‘WATER UTILITY INTEGRATION IN HUNGARY: IMPACTS AND FUTURE EXPECTATIONS
	(OECD, 2020)	OECD (2020) *Water sector: financing water supply, sanitation and flood protection*
	(Duffy, 2016a)	Duffy, K. et A. (2016) *Report on the Funding of Domestic Public Water Services in Ireland November 2016 Contents*
	(ASSMANN, 2016a)	ASSMANN, M. (2016) ‘Branchenbild der österreichischen Abwasser wirtschaft’
3	(Government of Hungary, 2017)	Government of Hungary (2017) *National Water Strategy*
	(American Water Works Association, 2010)	American Water Works Association (2010) *BURIED NO LONGER: Confronting America’s Water Infrastructure Challenge*
	(SZÁZADVÉG, 2016)	SZÁZADVÉG (2016) *ACTION PLAN On the tasks related to the proposals for the water utility sector of the Kvassay Jenő Plan 2016*
	(OECD, 2009)	OECD (2009) *Managing Water for All an OECD perspective on pricing and financing*
	(Kovács, 2020)	K. Kovács (2020) ‘Water utility asset management in Europe’
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	(OECD, 2020)	OECD (2020) *Water sector: financing water supply, sanitation and flood protection*
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	(Duffy, 2016a)	Duffy, K. et A. (2016) *Report on the Funding of Domestic Public Water Services in Ireland November 2016 Contents*
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HYPOTHESIS	SOURCE CITED	WORKS CITED
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	(Ernst Basler und Partner AG, 2007)	Ernst Basler und Partner AG (2007) ‘Wasserwirtschaft Schweiz 2025.’
	(ASSMANN, 2016a)	ASSMANN, M. (2016) ‘Branchenbild der österreichischen Abwasserwirtschaft’
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4. Basic data and findings of the research

By presenting my findings, in the current chapter I attempt to reveal the extent to which specific costs per capita of the development and replacement of infrastructure, on which water utility services are based, vary by settlement size. Furthermore, I will analyse the distribution over time of such costs in the urban settlements in question, to determine the extent to which the tariffs applied cover such costs. I will also look at the willingness of the population in the given settlement size to share in the bearing of burdens and their openness to horizontal and vertical solidarity. Supported by various mathematical and statistical methods, I explore the factors that may influence per capita replacement needs, on the one hand, and engagement serving the sustainability of water supply, on the other. These factors include asset value, the indicator of the status of the infrastructure, geographic location, settlement density, settlement size, number of real properties connected to the network, length of pipeline per capita, service provider affiliation, service tariffs, value of residential property, income levels, attitude towards solidarity, etc.

4.1 Basic research data and data structure

Basic research data were compiled using the asset valuation and engineering data in the MIAD database, and various economic, sociology and other characteristics from other sources (KSH, HEA) pertaining to the urban settlements selected. The analysis and examination of Hypothesis No. 5. are based on the data from the database built on a 5000-strong sample of the HWA WATERVALUE research, with the final evaluation done by combining the two databases. Asset valuations were done between 2014-2018. Of the total MIAD database, 714 settlements were included in the research, where there is both a drinking water and a wastewater branch, and where asset valuation was completed in both areas. The reason I thought that the existence of data for both branches was important, is because this allows the analysis of the characteristics of infrastructure implemented at different times and at different pace in the various branches, as known from preliminary research of the reference literature, in a breakdown by branches, as well as in a combined fashion.

The MIAD database by sectors (water, wastewater) of the asset valuation includes technical, as well as economic data by settlement, detailed by objects:

- Name/identification of object, positioning, principal technical characteristics (e.g.: network length, material, diameter, capacity, other technical parameters), expected lifetime, year of establishment, consistency index, specific investment/replacement (reproduction) value, asset value, owner.

Data by settlement lines were supplemented by other data linked to the subject matter of my research. Other data were taken from the publicly available database of the KSH and HEA, related to municipalities.

The following chart shows my final research database, the structure of the resulting data matrix and their explanation:

2. TABLE: DATABASE STRUCTURE

Columns of data matrix chart	Data source	Description
Settlement	KSH Urban settlements in Hungary	714 of the settlements in MIAD database, where asset valuation has been done for both the drinking water and wastewater service, broken down by branch
County	KSH Counties of Hungary	County of the settlement
Number of inhabitants	KSH Demographic data 2018	Number of inhabitants in the settlement
Based on number of inhabitants (person/settlement) (CODE)	Classification based on number of inhabitants	1 <100; 2 101-500; 3 501-1000; 4 1001-2000; 5 2001-5000; 6 5001-10000; 7 10001-50000; 8 50001-100000; 9 > 100001
Service provider	Water utility service providers with HEA licence	Water utility service provider in the given settlement
Service provider (CODE)	Licenced service providers with code No.	Code No. of water utility service provider in the given settlement
Aggregate replacement costs during the lifecycle reviewed - OPK (HUF)	MIAD database (calculated)	For settlements included in the study, in line with the methodology of the valuation, a 50-year aggregate figure based on the replacement costs of water utility (drinking water, wastewater, combined) objects, the year of establishment and the expected lifetime (recurring, in the case of assets with a short lifetime)
Aggregate replacement costs in the drinking water branch during the lifecycle reviewed - OIPK (HUF)	MIAD database (calculated)	For settlements included in the study, in line with the methodology of the valuation, a 50-year aggregate figure based on the replacement costs of drinking water utility objects, the year of establishment and the expected lifetime (recurring, in the case of assets with a short lifetime)

Columns of data matrix chart	Data source	Description
Aggregate replacement costs in the wastewater branch during the lifecycle reviewed - OSZVPK (HUF)	MIAD database (calculated)	For settlements included in the study, in line with the methodology of the valuation, a 50-year aggregate (net, exc. VAT) figure based on the replacement costs of wastewater utility objects, the year of establishment and the expected lifetime (recurring, in the case of assets with a short lifetime)
Per capita replacement costs during the lifecycle reviewed - OPK/capita (HUF/capita)	MIAD database (calculated)	For settlements included in the study, per capita (net, excl. VAT) value calculated on the basis of the number of inhabitants in the settlement, from the Aggregate Replacement Costs incurred during the lifecycle reviewed
Pipe-length per capita (water-wastewater) (rm/pp)	MIAD database (calculated)	For settlements included in the study, based on the asset valuation, the sum of drinking water and wastewater network length in the given settlement, calculated per capita, based on the number of inhabitants
Settlement density in county (No./100 km^2)	KSH database	Settlement density in the given county
Number of residences connected to the drinking water network, total - 2018	KSH, Tables (STADAT) – Timeline annual, territorial data - Environment	Number of residences connected to the drinking water network based on data supplied to the KSH by water utility companies
Number of residences connected to the wastewater collection network (pcs) - 2018	KSH, Tables (STADAT) – Timeline annual, territorial data - Environment	Number of residences connected to the wastewater collection network based on data supplied to the KSH by water utility companies
Average price of used flats sold (million HUF /flat) - 2018	KSH Number and average price of used flats sold	Average price of flats sold in the given settlement
Amount of personal income tax base (HUF 1000)	Annual statistical data for urban settlements, 2018 settlement structure	Amount of personal income tax base in the given settlement
Personal income tax base per capita per month 2018	Annual statistical data for urban settlements, 2018 settlement structure	The amount of personal income tax base for the given settlement divided by the number of months and the number of taxpayers in the settlement
Domestic water-sanitation charges total (HUF/ m^3) - 2019	HEA data	Domestic charges were calculated using the following method: (gross, including 27% VAT: HUF/person/m^3): domestic base charge for the settlement, plus the consumption-based per capita charge per month, calculated from the 5 m^3 consumption per household and 2.36 persons per household on average, and this amount then divided for 1 m^3 based on calculated consumption
Water supplied for 1 person (m^3) - 2018	KSH, Tables (STADAT) – Timeline annual, territorial data - Environment	Volume of water supplied to 1 person in the given settlement, based on the data supplied to the KSH by the water utility companies

Columns of data matrix chart	Data source	Description
Volume of (household) wastewater discharged in the public utility wastewater network per 1 person (m^3) - 2018	KSH, Tables (STADAT) – Timeline annual, territorial data - Environment	Volume of (household) wastewater discharged per 1 person in the given settlement, based on the data supplied to the KSH by the water utility companies
Total replacement value - OPÉ/person (HUF/person)	MIAD database	For settlements included in the study, in line with the methodology of the valuation, replacement value for the given settlement (cost value established upon valuation of the one-off replacement of total water utilities (net, exc. VAT)), calculated per person
Total asset value – OVÉ/person (HUF/person)	MIAD database	For settlements included in the study, in line with the methodology of the valuation, asset value for the given settlement (value adjusted by obsolescence determined upon valuation (net, excl. VAT) of the single replacement value of the total water utilities) calculated per person
Average consistency index = OVÉ/OPÉ	MIAD database	For settlements included in the study, in line with the methodology of the valuation, ratio of asset value vs. replacement value for the given settlement
Annual depreciation - OÉCS1 (HUF/person/year)	MIAD database	Value per person of the annual depreciation of water utilities in settlements included in the study (net, excl. VAT), calculated for the Total replacement value
Accountable annual depreciation - OÉCS2 (HUF/person/year)	MIAD database	Value per person of the annual depreciation of water utilities in settlements included in the study (net, excl. VAT), calculated for the Total asset value
Replacement cost per person incurred between 0-15 years - OPK15 (HUF/person)	MIAD database	For settlements included in the study, in line with the methodology of the valuation, values summarised in annual breakdown, in a 50-year timeline, calculated from the replacement values of the individual objects, based on their expected lifetime (recurring, in the case of assets with a short lifetime) and on the expected date of their replacement, sum of replacement values for a given settlement for the first 15 years (net, excl. VAT)
TOP-HEAVINESS INDICATOR (ratio of opk15/opk35)	MIAD database	For settlements included in the study, ratio of the sum of replacement values for years 1-15 and years 16-50 as per OPK 15

4.2 Analyses, statistical methods used in the research

In my analysis, the data matrix summarised by settlement is examined in two main steps. The analysis focuses primarily on the examination of per capita replacement costs, the OPK/person index per settlement and its influencing factors, together with the justification of the related hypotheses. As a second step, the combined database supplemented by the Watervalue research data is analysed, including the analysis of the possible solutions for the financing problems, which surfaced in the course of the research. Subject matter of the study: total replacement cost per person (OPK/person) during the lifecycle examined (HUF/person) and examination of funding sources for the costs.

Study units: Urban settlements

Number of units (N): 714

Statistical methodology applied

- Descriptive statistics: summary indicators
- Correlation analysis, correlation matrix: proximity and direction of the relation between our potential explanatory variables is determined
- Linear regression (Establishment of the relations determining the value of OPK/person)
- Cluster analysis: grouping urban settlements based on similarities

Tools used in the course of the statistical research: SPSS 25, EXCEL (Microsoft 365)

Data analysis

Explanatory variables examined: see **Table 3. Database structure**

4.3 Presentation of findings

The per capita Aggregate Replacement Costs (OPK/capita) indicator, as a dependent variable, was generated and selected, based on professional evaluation, from the multitude of data available in the research. The significance of this indicator lies in that it provides, using a lifecycle approach, the total cost of all replacement needs arising during the life of the infrastructure, on which water utility services are based. At the same time, it shows the value, the non-recovery of which means that water services are not sustainable. The analysis of OPK/capita, as a dependent variable and its influencing factors, including pipe length per capita, settlement density, service charges, income relations, number of dwellings connected to the service, their value, etc. (see Table 2.), allows the discovery of in-depth connections to prove the hypotheses presented in chapter 3.6. Looking at the possibilities of raising the funding for the total replacement costs showing substantial variation by settlements and settlement size groups, I further analysed the individual willingness to engage socially and the generational readiness for solidarity among settlements grouped by size. In the following sections, I endeavour to present the analysis using various, partly descriptive statistical methods, of the per capita replacement cost indicator, OPK/capita, studied for the purpose of my hypothesis.

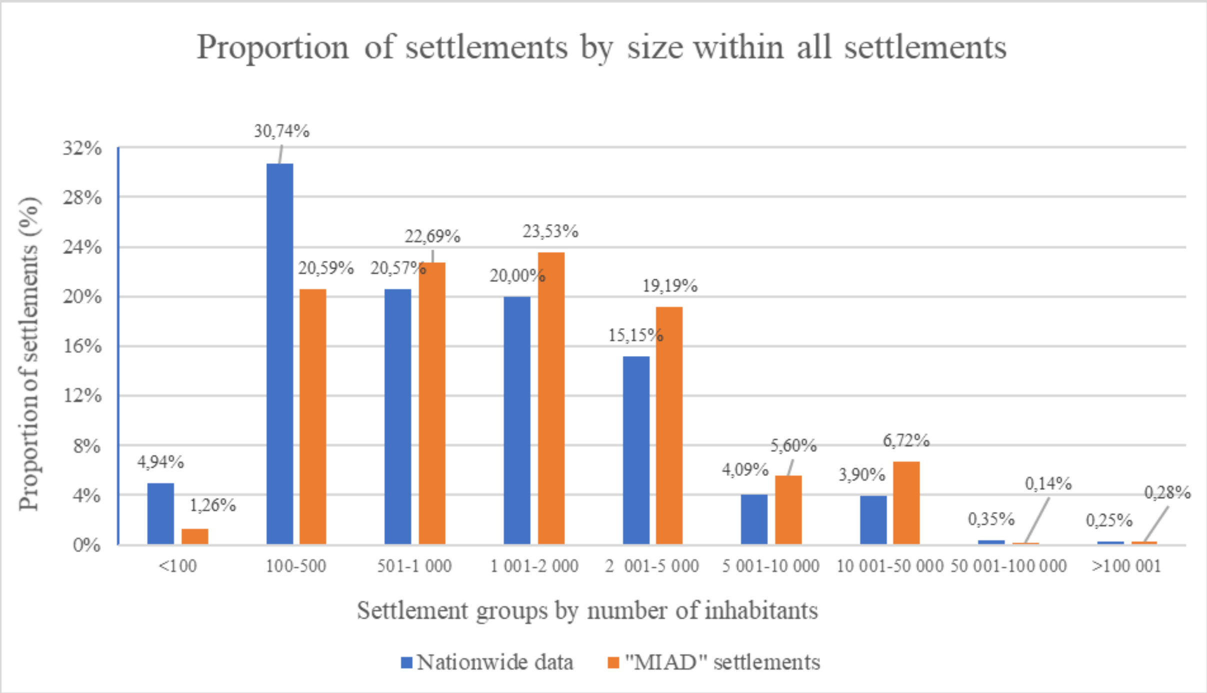
In the course of the study, I analyse the variables with an actual, significant impact, influencing the development of replacement costs (OPK/capita). In the study, I am looking for the real explanatory variables (predictors) of the OPK/capita. I study the relations among potential explanatory variables, their proximity and direction (correlation analysis) and take a look at their explanatory power (linear regression). Of the multiple statistical methods, I use cluster analysis to group the settlements, using the integrated database that includes data and review consideration revealed in the Watervalue research.

4.3.1 Statistical analyses by settlement groups

The urban settlements to be studied were divided into 9 groups by size (see Table 3.). Comparing the ratio of the settlements studied within the settlement groups to the same indicator of all settlements in Hungary, it can be concluded that the size distribution of the 714 settlements in the sample duly represents the national distribution (among 3055 urban settlements) (see Fig. 9.)

3. TABLE: GROUPING BASED ON NUMBER OF INHABITANTS

Code	Size of settlement by number of inhabitants	Total population	Number of settlements
1	<100	653	9
2	100-500	43 748	147
3	501-1 000	116 997	162
4	1 001-2 000	242 238	168
5	2 001-5 000	406 276	137
6	5 001-10 000	278 371	40
7	10 001-50 000	942 556	48
8	50 001-100 000	66 791	1
9	> 100 001	264 110	2
	Total:	**2 361 740**	**714**



10. FIGURE: COMPARISON OF SIZE DISTRIBUTION OF SETTLEMENTS STUDIED WITH SIZE DISTRIBUTION OF ALL HUNGARIAN SETTLEMENTS

According to Hypothesis 1.: "*The replacement costs per inhabitant, of infrastructure on which water utility services are based, show significant differences in urbans settlements of different sizes, with the difference being of orders of magnitude at the extreme values, where the value in smaller settlements is several times higher than in larger settlements.*"

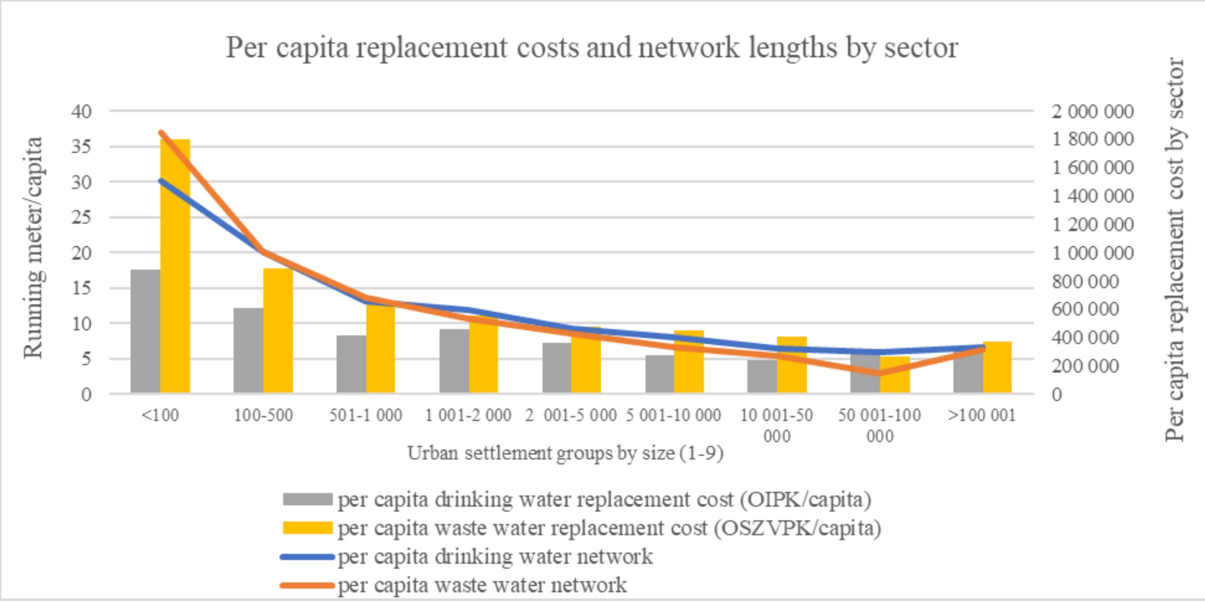
Table 4. shows the average values by settlement groups (1-9) of the total per capita replacement cost expressed in HUF. The table also shows service charge data to support the justification of additional hypotheses. The graphic representation and the analysis of the connections of these data are shown below

4. TABLE: AVERAGE VALUES BY SETTLEMENT GROUPS (1-9) OF THE TOTAL PER CAPITA REPLACEMENT COST AND SERVICE CHARGES

Settlement group	Average OIPK/capita (HUF/person)	OSZVPK/capita average (HUF/person)	Average OPK/capita average (HUF/person)	Average OPK/capita/year (HUF/person/year)	Average water-wastewater charge (HUF/m^3) - 2019	Average fee per person paid in a year
1	859 404	1 813 714	2 696 426	52 871	786	28 315
2	589 255	904 379	1 517 845	29 762	778	23 145
3	397 812	671 727	1 089 382	21 360	781	21 258
4	449 543	558 037	1 016 006	19 922	775	24 238
5	357 322	476 027	839 391	16 459	723	22 515
6	272 390	460 820	737 695	14 465	678	23 229
7	235 845	412 541	651 232	12 769	662	22 764
8	287 750	264 051	566 621	11 110	695	23 721
9	213 248	368 352	501 330	9 830	622	20 825
Grand total average of groups 1-9	**428 862**	**639 060**	**1 081 082**	**21 198**	**753**	**22 892**

It can be established that in accordance with the hypothesis, the per capita average values by settlement group of the total replacement cost incurred during the 50-year cycle analysed (as a sectorial total OPK, as well as broken down by sector OIPK and OSZVPK) **exceed the values of the settlements with a population in excess of 100.000 inhabitants by a multiple of about 5 in the case of settlements with a population of less than 100 people and by a multiple of 2, even in settlements of between 1.000-2.000 people. The per capita average values by settlement group of the total replacement cost is calculated as the average of the per capita values of the settlements within the given group of settlements.** It is important to note that the grand total average values of groups 1-9 were calculated as the weighted average the total replacement values and total fee payments of the entire sample (714 settlements) divided by the total number of population of the sample, 2.361.740 people.

I have incorporated the average per capita network length figures by settlement group into Figure 11, illustrating the replacement cost lines of Table 4, thus demonstrating the relationship already partly known from the Austrian example between the size of the urban settlement and per capita network length, highlighting the relationship between replacement values and network length. **In proportion with the replacement costs, per capita network length is the highest in the smallest settlements. In settlement group 1. (with a population of less than 100 people), the length of the drinking water network is 4,5 times, the length of the wastewater network is more than 5 times that of the per capita network length in settlements within settlement group 9.**



11. FIGURE: **PER CAPITA VALUE OF REPLACEMENT** COSTS OF WATER UTILITY SYSTEMS

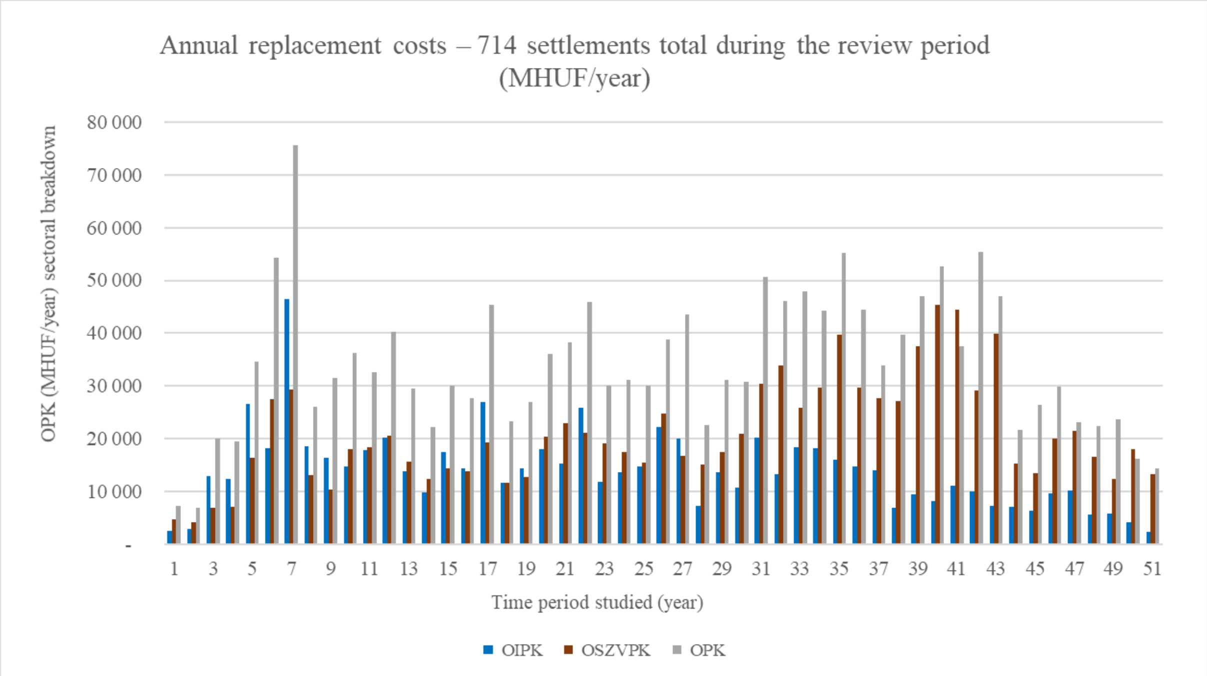
According to Hypothesis 2.: *The average (spread evenly over time) cost requirements of sustaining and replacing the water utility infrastructure are considerably higher than the funding afforded in the current service environment (tariff structure). To make matters even worse, replacement needs vary greatly over time because of the age distribution and technical condition of the water utility infrastructure. For drinking water supply systems, this value is extraordinarily high for the near future (next 15 years).*

The truth of the first statement within this hypothesis is evidenced by values summarised in Table 4. for settlement groups 1-9, on the annual average per capita replacement needs (HUF 21,198/person/year) and the annual average fee paid per person (HUF 22,892/person/year). By way of clarification, it must also be noted that, while replacement needs are net values (excl. VAT), water charges include 27% VAT. Thus, duality is present in both the research and the evaluation, since while VAT can be reclaimed for investments, domestic consumers are required to pay this VAT content, striking in more ways than one. This is a factor to be reckoned with when analysing affordability issues. The fact that the net value of the total annual fee income (HUF 18,025/person/year) is nearly 20% lower than the annual replacement needs, means that Hypothesis 1. is true without any analysis of the other costs of water supply. Average tariffs fail to cover even replacement needs evenly distributed in time and among the settlements of the entire sample!

The comparison of annual average per capita replacement values by settlement group, either consolidated or by sector and the annual fee payments broken down the same way are shown in an itemised fashion in Fig. 21. within the analysis of Hypothesis 4. Before that, however, to analyse the second statement of Hypothesis 2., let us take a look at the characteristics of the distribution over time of the replacement needs and the size distribution of replacement needs per year. These distributions over time on the one hand and in by orders of magnitude on the other are analysed through simple descriptive statistical means and indicators (standard deviation, relative deviation, skewness and kurtosis) and through the introduction of an indicator of my own (top-heaviness indicator) intended to better illustrate the data, as well as through diagrams.

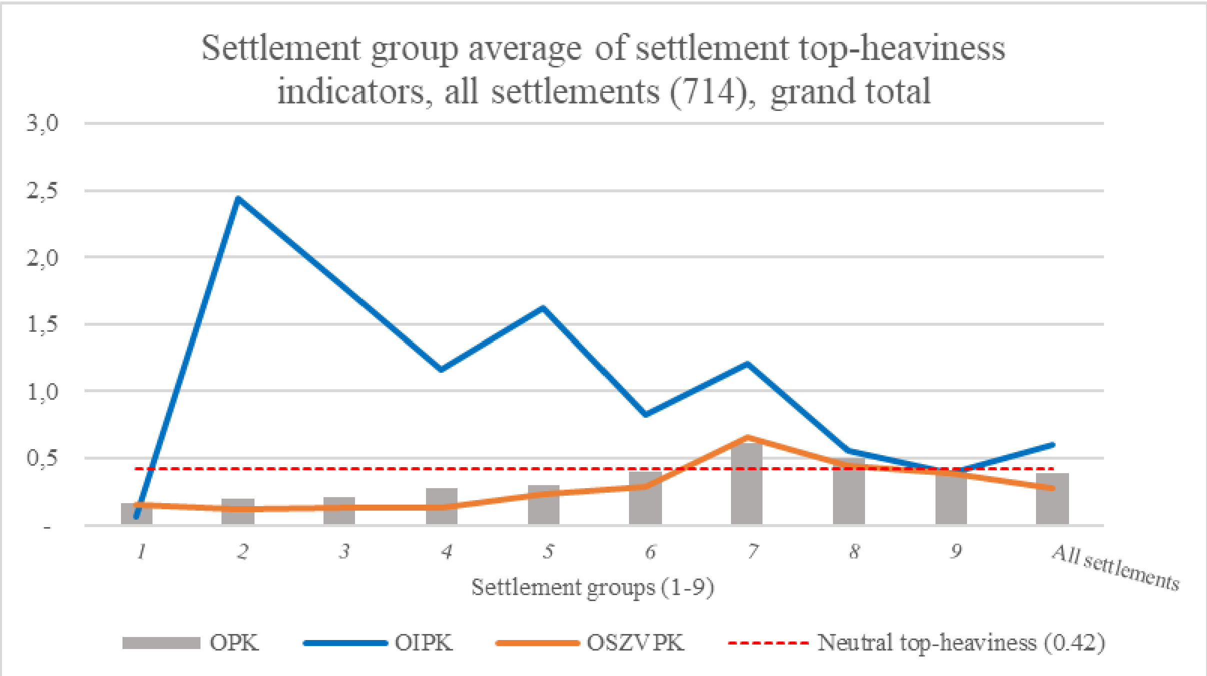
The total replacement needs of HUF 1,748 billion present in the 714 urban settlements over a 50-year time period, distributed over time, in the water and wastewater sectors are shown in the bar chart of Fig. 13. The diagram follows a comb-like pattern with the occasional outliers. The replacement values for the given years are calculated through by summarising the replacement needs of the various urban settlements in the given year.

Looking at the individual years and periods, it becomes clear that in years 6-7 of the review period, replacement values present some outliers. These outliers, and the fact that years 1-5 show lower values are the consequences of the rules for the valuation of public utility assets, according to which the consistency index of assets used have to be set at minimum 10% of the planned lifetime, regardless of their consistency and readiness to be replaced. This means that depending on the time of the valuations, the replacement of assets with a planned lifetime of 50 years, occurs in year 5. following the valuation. Thereafter, all replacement needs occur fairly evenly distributed, with a comb-like pattern, though. Breakdown by sector reveals, however, that within all replacement needs the ratio of the drinking water sector is more significant during the coming years and the overall higher replacement needs of the wastewater sector are experienced in the second half of the review period.



12. FIGURE: ANNUAL REPLACEMENT COSTS DURING THE REVIEW PERIOD (MILLION HUF/YEAR)

To substantiate and illustrate the professional evaluation, I have developed the top-heaviness indicator (see Table 2. for its interpretation)

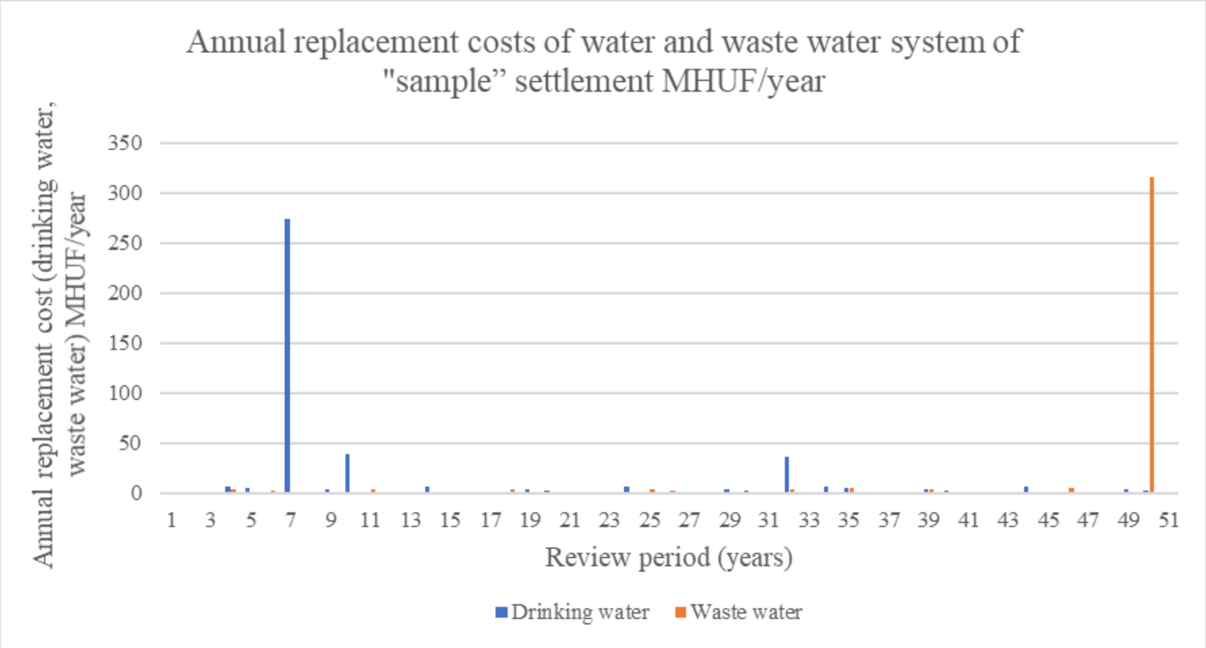


13. FIGURE: SETTLEMENT GROUP AVERAGE OF SETTLEMENT TOP-HEAVINESS INDICATORS, ALL SETTLEMENTS (714), GRAND TOTAL

The top-heaviness indicator shows whether it is during the first 15 or last 35 years of the 50-year period reviewed, that higher replacement costs are incurred. Anything above the value of 0.43 (15/35=0.43) showing an even distribution over time, means that the water utility systems are “top-

heavy", i.e., a higher-than-average portion of the 50-year replacement costs is incurred during the first 15 years. Under the 0.43 value, the distribution of the replacement costs of water utility systems is so-called "bottom-heavy", i.e., a higher-than-average portion of the 50-year replacement costs is incurred during the last 35 years. The above diagram shows the top-heaviness indicator by settlement groups, calculated as the average of the top-heaviness indicators of the settlements within the group, an exception being the summary value for the 714 settlements, calculated from the summary replacement figures in order to consider the weighted figure for the replacement values of the different settlement groups. **Based on the above figure, we can conclude that drinking water systems tend to be "top-heavy", whereas wastewater systems tend to be "bottom-heavy" in almost all settlement groups.** Exceptions to the above general observation are settlement groups 1 (0-100 inhabitants), 7 and 8 (10,001-50,000; 50,001-100,000 inhabitants, respectively). In the micro-settlements in group 1., piped water networks and subsequently wastewater sewerage systems were built during the last 35 years, i.e., in the last wave of constriction of urban water supply systems. Consequently, there is no significant replacement need during the next 15 years either in the drinking water or in the wastewater sectors. In the case of settlement groups 7. and 8., the refurbishment needs of the sewer systems built in the 1960's and 70's arise during the 15 years following the valuation, thus those systems are also top-heavy. **To quantify the urgent refurbishment needs anticipated in scientific references, it must be noted: in settlement groups 2-7, water supply infrastructure will require one and a half to twice as much spent during the coming 15 years than during the 35 thereafter in total!**
In group 9, of settlements with more than 100,000 inhabitants, the replacement needs are evenly distributed as a result of the gradual development of both the water and the sewerage networks. Marked top-heaviness is eliminated through the consolidation of the water and wastewater sectors, i.e., the consolidation of the asset management of the sectors allows for more balanced replacement and financial planning. As is seen from the consolidated replacement values of the 714 settlements, compared to an evenly distributed situation, in the field of water supply there is a 1.5-times top-heaviness, whereas in the field of sewerage systems there is a bottom-heaviness of the same magnitude, consolidating which can lead to a balance of the 15-35-year period.

Before moving on in analysing the consolidated data of the settlements grouped by size, it is essential to see the replacement timeline for settlements with less than 5,000 inhabitants, which tends to be the more extreme outlier as the smaller the settlement is and tends to follow the following pattern increasingly markedly. The "marked" trend in replacement needs is shown in Figure 14., on the example of a "Sample" settlement (number of inhabitants: 2,500 people) from group 5. (2,000-5,000 inhabitants).



14. FIGURE: ANNUAL REPLACEMENT COSTS OF "WATER AND WASTEWATER SYSTEM OF "SAMPLE" SETTLEMENT MILLION HUF/YEAR

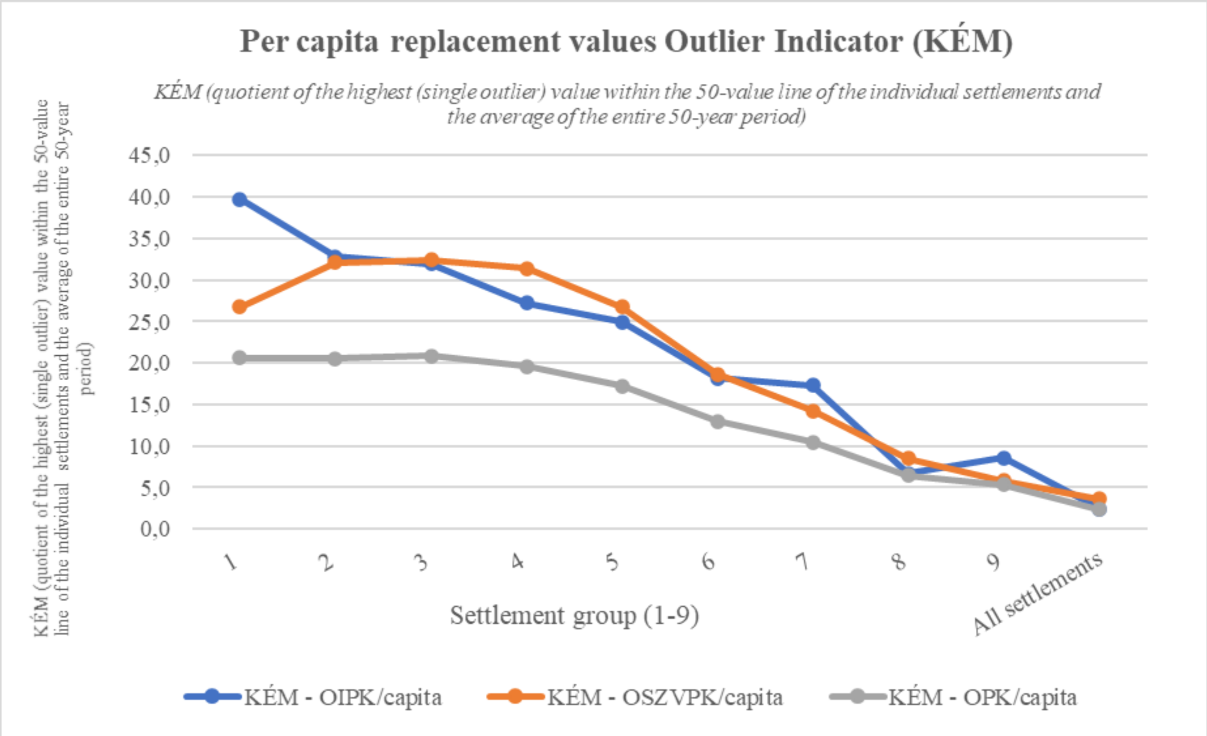
The top-heaviness indicator of the given settlement is 3.97 in the case of water, i.e., the settlement is rather “top-heavy”. The amount of replacement costs incurred during the first 15 years is about four times the amount of the replacement costs during the last 35 years. The “top-heaviness” indicator for wastewater is 0.03, i.e., the settlement is markedly “bottom-heavy”, i.e., the amount of replacement cost during the first 15 years is minimal, thus the total replacement cost during the last 35 years is some 30-times higher than that of the first 15 years. At the same time, the outliers in each year make up 80-90% of the replacement needs of the total timeline, which, if divided over the years preceding and following the due date, presents a nearly unsurmountable challenge for the asset management of the given settlement.

The outliers present at various points in time are characterised as the Outlier Indicator calculated from the quotient of the highest replacement need value presented in the given settlement within a year and the average value of the 50-year data line.

On this basis, we can conclude that:

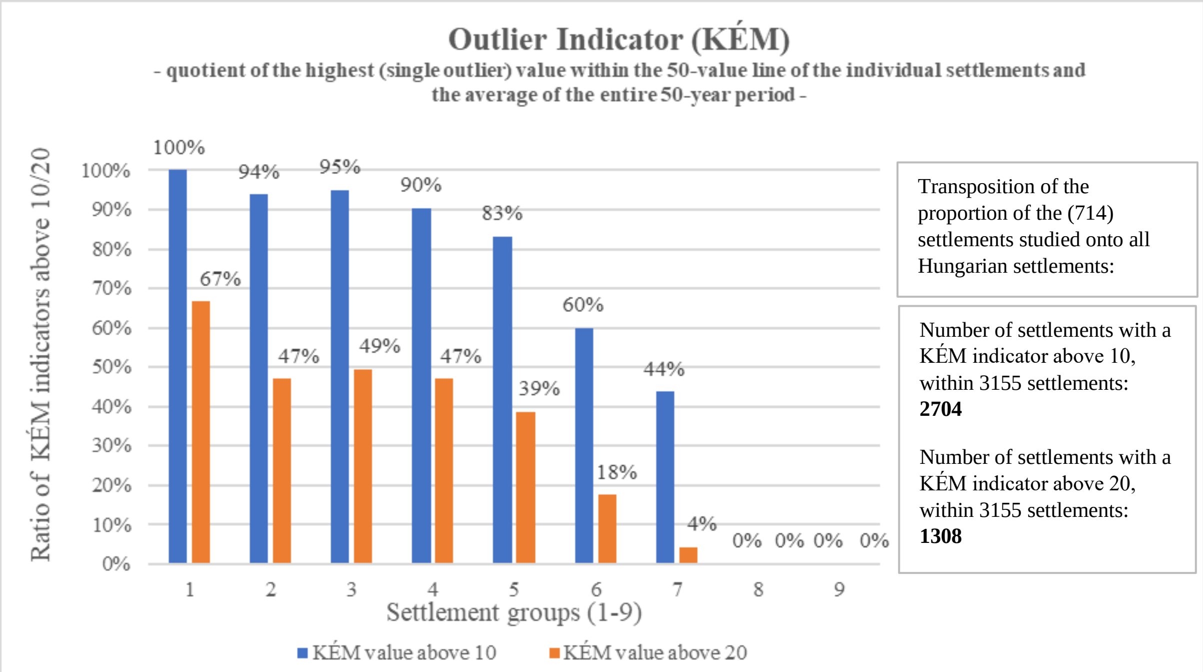
- In small settlements, at a disadvantage also in terms of the per capita replacement needs, (where fees do not provide funding for the average replacement values even)
- The extreme high outlier values (exceeding the average by a factor of 30-40) present sporadically at the level of the individual settlements (as independent asset

manager owners and service providers) make asset management entirely impossible at the level of the individual settlement.



15. FIGURE: OUTLIER INDICATOR (KÉM) CALCULATED FROM THE QUOTIENT OF THE HIGHEST REPLACEMENT NEED VALUE PRESENTED WITHIN A YEAR AND THE AVERAGE VALUE OF THE 50-YEAR DATA LINE

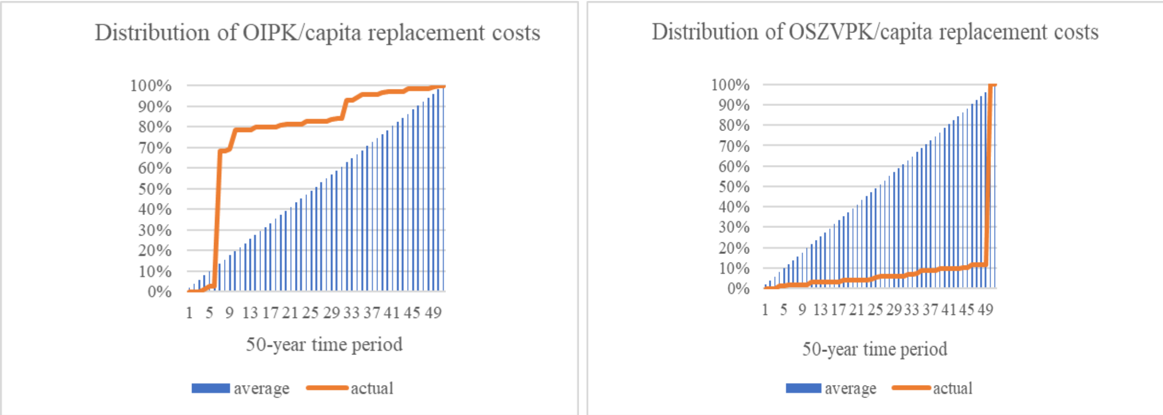
It is important to see that this distribution is characteristic for both the settlements studied and - due to the national urban structure - for more than 80% of domestic urban settlements!



16. FIGURE: DISTRIBUTION OF SETTLEMENTS WITH A KÉM INDICATOR ABOVE 10 AND ABOVE 20, WITHIN THE URBAN STRUCTURE STUDIED AND NATIONALLY

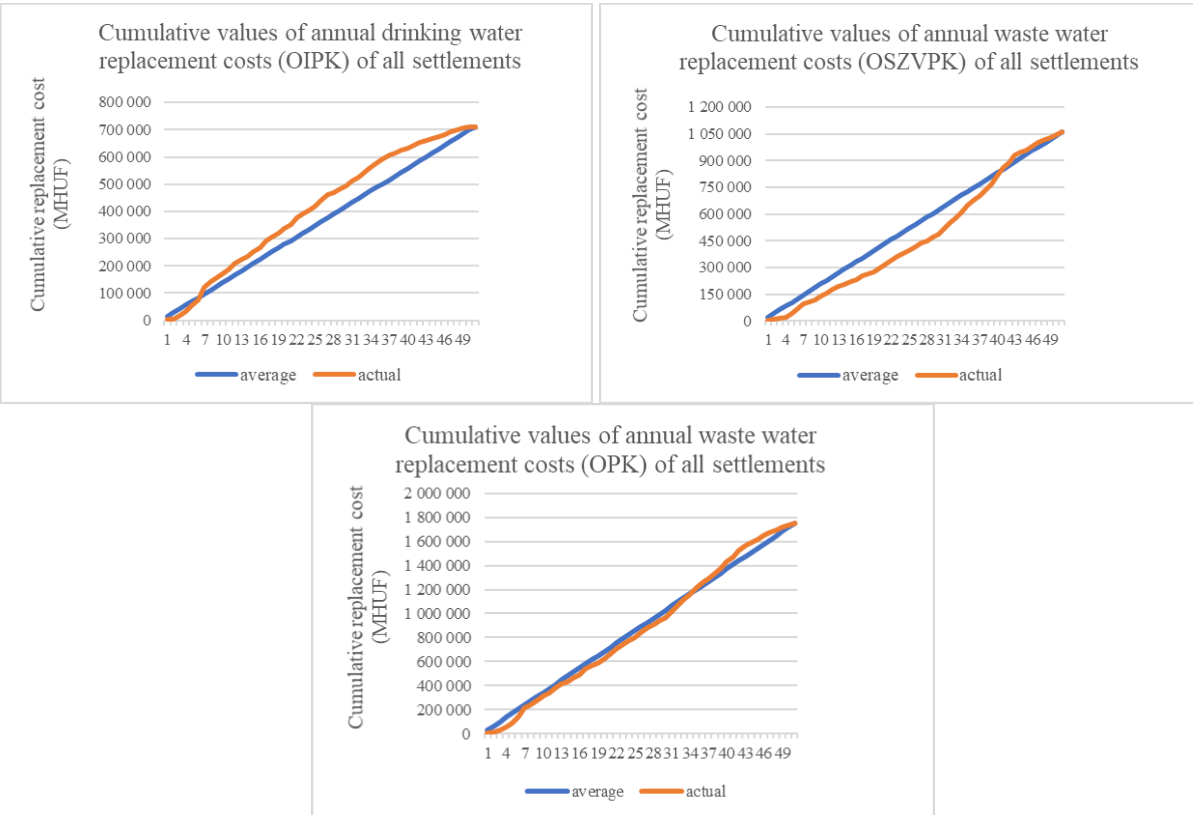
Before analysing the classic statistical standard deviation figures, in order to allow further analysis and demonstration of the distribution within the review period of the annual replacement costs, I have shown the cumulative actual annual replacement cost amounts, as well as the linearly growing (evenly distributed) average values of replacement costs for the review period of settlements and settlement groups in a coordinate system similar to the Lorenz curve approach.

The novel presentation of the distribution of replacement costs begins with the actual data of the Sample settlement already introduced in the bar chart of Figure 14. Based on the data line of the 50-year replacement cost of the settlement, the distribution presented above is as follows on the Lorenz curve diagram:



17. FIGURE: A DISTRIBUTION OF REPLACEMENT COSTS OF "SAMPLE" SETTLEMENT IN A SECTORIAL BREAKDOWN, DURING THE REVIEW PERIOD (50 YEARS)

The following diagram (Fig. 18.) shows the distribution curve of the replacement costs incurred annually in all settlements during the time horizon studied:



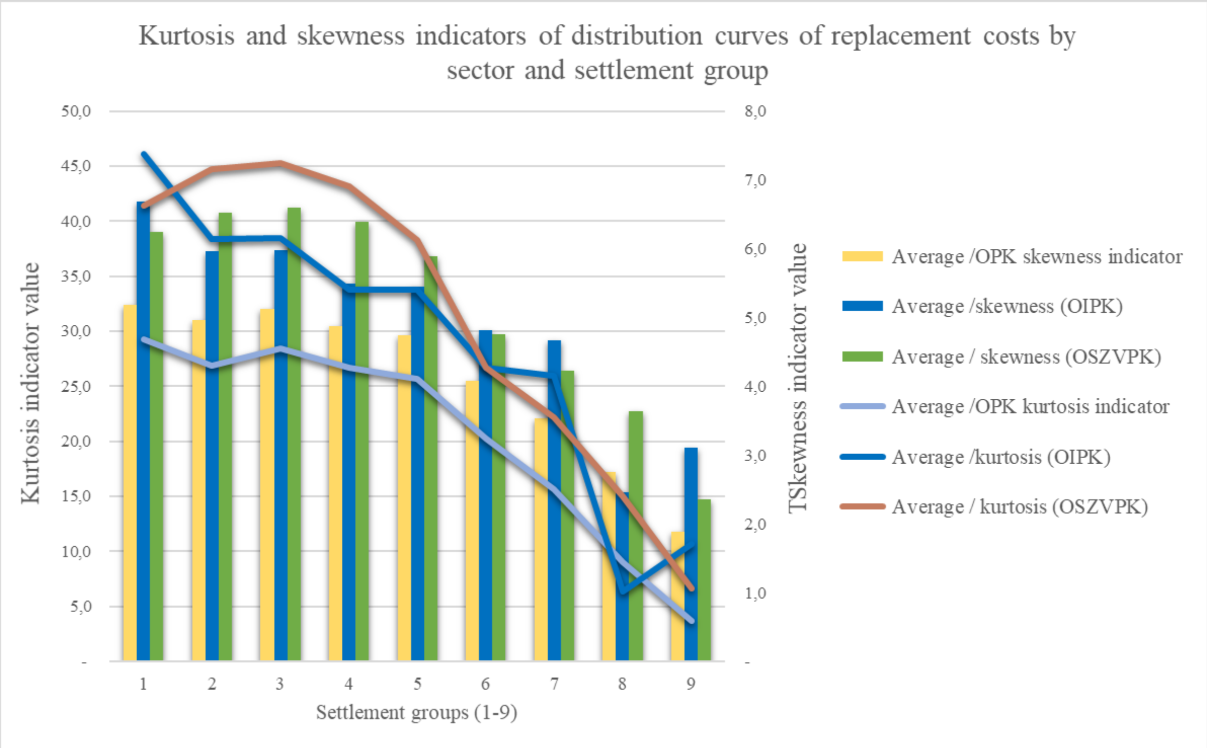
18 FIGURE: CUMULATIVE VALUES OF ANNUAL REPLACEMENT COSTS (OPK) OF ALL SETTLEMENTS

The key findings of the interpretation of the above distribution curves are as follows:

- 0 or significantly lower-than-average replacement costs for the first 5-year period are the consequence of the valuation methodology described earlier in detail, thus they become due in year 5. following the valuation, at the earliest.

• Similar to the top-heaviness indicator, consolidating the sectors leads to the elimination of the differences from the average in terms of time. This means that the balance in water utility asset management is improved as we move towards larger and more consolidated in terms of sectors systems.

When analysing the distribution of replacement costs incurred per settlement during the 50-year review period, I also studied the distribution, variation and kurtosis and skewness indicators of annual replacement values per settlement. These values are presented in Figure 18. in averages by settlement groups.



19. FIGURE: ANALYSIS OF DISTRIBUTION OF REPLACEMENT COSTS INCURRED BY SETTLEMENT DURING THE 50-YEAR REVIEW PERIOD

The kurtosis indicator declines for both drinking water and wastewater as the size of the settlement increases. The higher kurtosis indicator for smaller settlements shows that the 50 individual replacement values for the given years, gleaned from the 50-year data lines of the given settlements remain low, in the majority of the years as low as 0, and are thus heavily represented in this range. The positive value of the skewness indicator shows that the median of the replacement data lines is lower than the average of the given data line, i.e., in both the water and wastewater sectors, and in all settlement groups outlier high values are characteristic for the individual years, thus raising the average and presenting the given settlements with a major challenge in terms of financing.

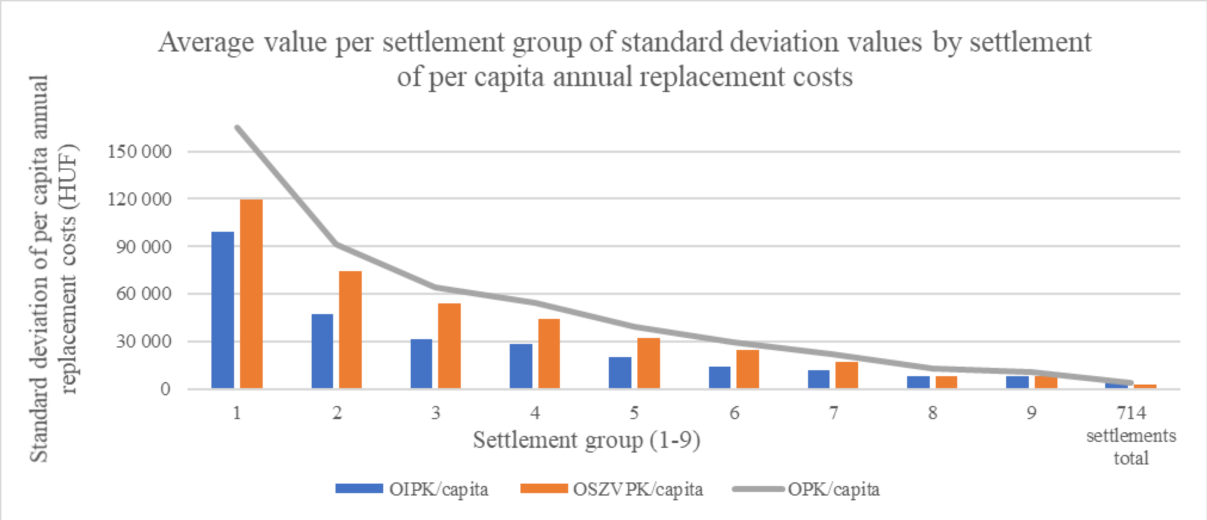
The skewness indicator presents the symmetry of the distribution curve of the review period. The above figure shows that upon higher kurtosis, the skewness indicator is of similar tendency, declining as the size of the settlement increases.

In line with above statements, as we move towards the systems of larger areas of supply, water utilities tend to be increasingly sustainable.

According to Hypothesis No. 3.: *The distribution over time of replacement needs varies by sector and settlement type, meaning that such needs are more concentrated in time, with higher outlier values in smaller settlements, and can in time become more balanced and as such better manageable in the tariffs through the consolidation of asset management among the sectors and through the regional management of municipal assets (regional consolidation of water utility systems).*

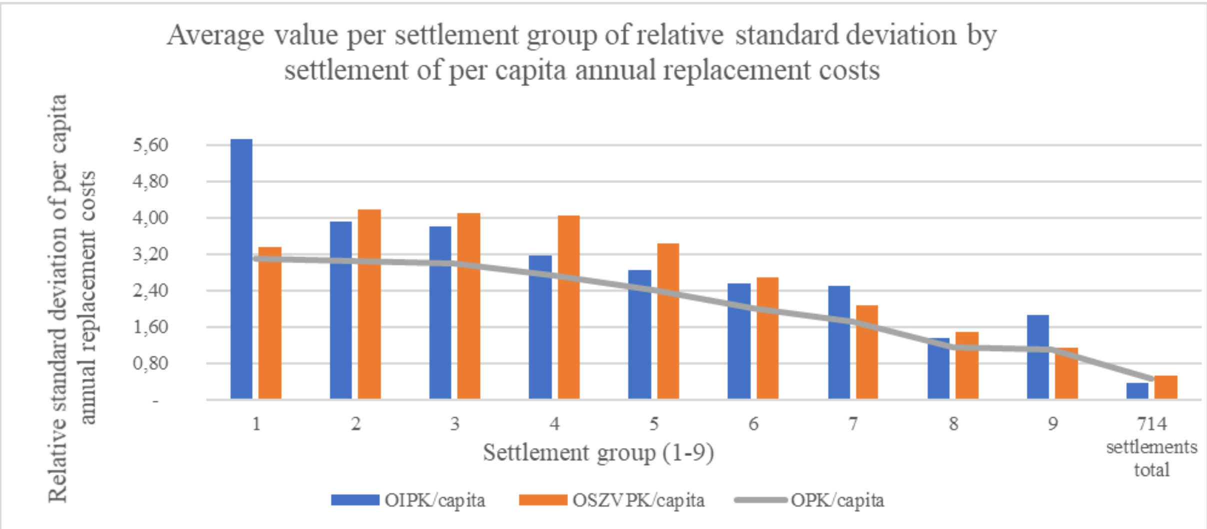
Looking at the values of the OPK/person indicator and the annual distribution of replacement needs, Figures 15-16 show that there are significant outlier values for both water and wastewater replacement costs in smaller settlements. These are typically incurred during the next 15 years in the case of water and during the last half of the 50-years studied in the case of wastewater. With small settlements, the reason for the presence of outlier values is primarily that the network was typically established in one year, representing more than 70% of replacement costs. Another reason for the presence of high replacement values is that in smaller settlements larger point-source water utility objects, including water works or wastewater plants are either missing or only available in some, thus their replacement value does not manifest during the 50-year review period either. In cities and larger settlements outlier replacement values are less characteristic, since urban water and wastewater networks were not built in one year and the replacement cost of point-source objects is incurred over multiple years, and in part recurringly.

The above can also be substantiated through the standard deviation values of the OIPK/person and OSZPK/person values of the database studied.



20. FIGURE: AVERAGE VALUE PER SETTLEMENT GROUP OF STANDARD DEVIATION VALUES BY SETTLEMENT OF PER CAPITA ANNUAL REPLACEMENT COSTS

In view of the fact that the extent of the standard deviation is also influenced by the average values, and as has been shown in Figure 11, in the case of small settlements, the average per capita replacement values are multiples of the same figures in larger settlements, to eliminate this effect, I have also looked at relative standard deviations.



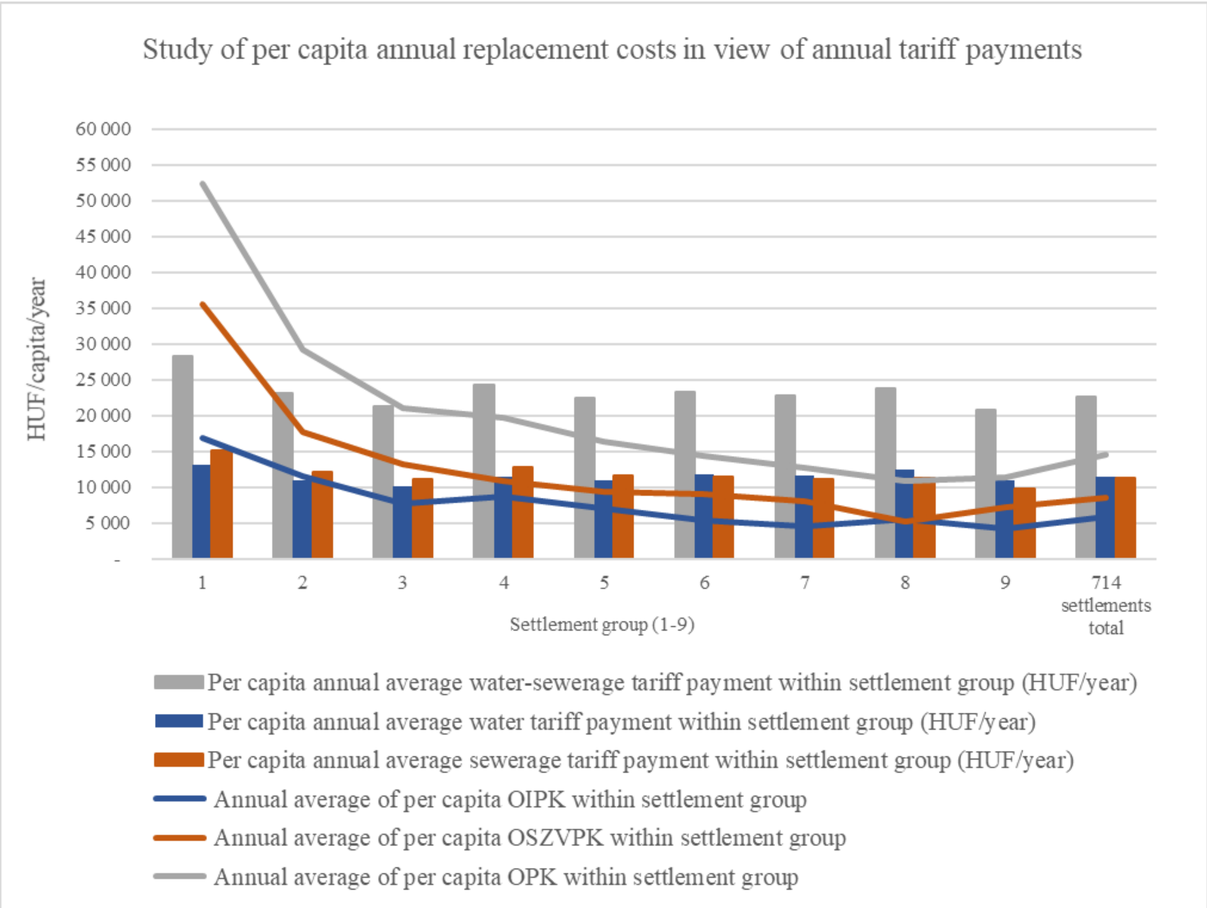
21. FIGURE: SETTLEMENT GROUP AVERAGE OF RELATIVE STANDARD DEVIATION BY SETTLEMENT OF PER CAPITA ANNUAL REPLACEMENT COSTS

It can be concluded, that in line with the hypothesis, the relative standard deviation of the per capita OPK/person is also highest in small settlement and is inversely proportional with the size of the settlement. As the above diagram shows, the standard deviation is greater in small settlements for both water and wastewater replacement costs. It is interesting to observe at the same time that while the standard deviation of the combined values of the two

sectors exceeded the values of the individual sectors studied separately, consolidating the replacement values of the two sectors lead to the decline in the relative standard deviation, compared to the separate relative standard deviation by sector. The outliner figures would be less marked in the case of smaller settlements, as well, if the asset management of the water and wastewater sectors, currently separate, as per the regulations in force, could be handled in a consolidated manner.

According to Hypothesis No. 4.: *The replacement values of the infrastructure are reflected in the service charges, which thus are significantly higher in smaller urban settlements than the service charges in cities.*

As has been anticipated when analysing Hypothesis No. 2. and can also be seen in a sectorial breakdown in the following diagram, service charges either do not cover, or only cover in part the replacement needs.

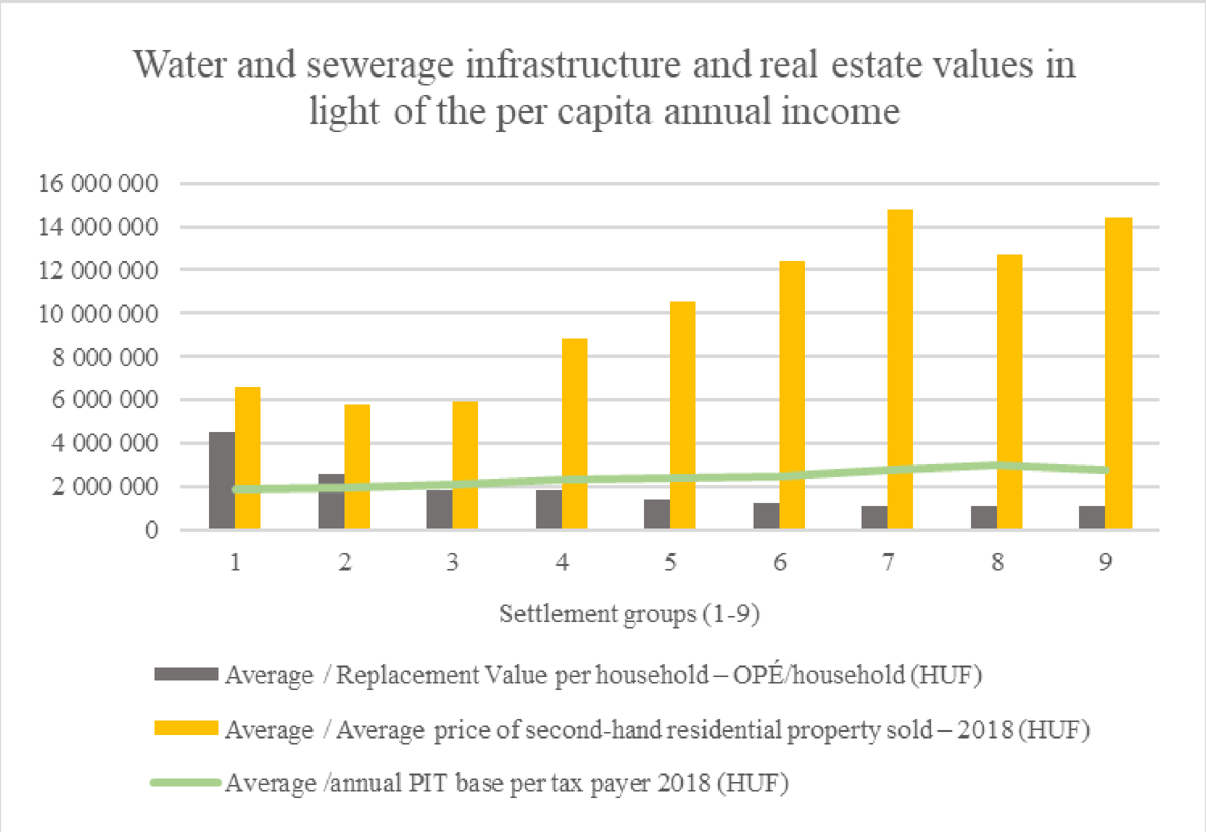


22. FIGURE: STUDY OF PER CAPITA ANNUAL REPLACEMENT COSTS IN VIEW OF ANNUAL TARIFF PAYMENTS

Despite the fact that there is a 5-fold difference in replacement needs between the two extremes of settlement groups (smallest vs. largest), this results in but a 40% additional burden on average in water and sewerage charge for the smallest settlements. Although the 40% extra burden can be considered substantial, substantiating in part the validity of Hypothesis 4., at the same time, looking at it from a different angle, what we see is that it does not nearly provide enough financial cover for the five-fold extra costs needed to cover replacement needs. Especially in light of the fact that the specific costs of operation and maintenance (although not the subject matter of my present research) are also higher in small urban settlements.

It is important to note that the grand total average values for groups 1-9 were calculated as the weighted average of the total replacement values of the entire sample (714 settlements) divided by the total number of inhabitants of 2,361,740.

The negative picture shown above is compounded by the fact that the annual per capita PIT base (income) in small settlements is lower than that of larger settlements. There seem to be surprising correlations between the Total Replacement Value (OPÉ) per real estate per household and the property value of used residential property sold in the given settlements or settlement groups. In the case of smaller settlements (with less than 1000 inhabitants), the replacement value of the water utility infrastructure represents nearly 50% of the market value of the given property, in the case of settlements with less than 100 inhabitants, the ratio is 70%.



23. FIGURE: AVERAGE VALUES OF OPÉ/HOUSEHOLD, PRICE OF REAL ESTATE SOLD AND INCOME SITUATION

In the following paragraphs, I present the study through various statistical methods of the OPK/person, the per capita replacement cost indicator, analysed for the purpose of my hypotheses. In the review, I analyse the variables with an actual, significant impact, having material effect on the way replacement costs (OPK/person) evolve. Through the study, I look for the real explanatory variables (predictors) of the OPK/person. As a first step, the relations among potential explanatory variables, their proximity and direction (correlation analysis) are analysed, then I look at their explanatory power (linear regression). Of the multivariable statistical methods, I use cluster analysis to break the settlements into groups based on the analysis criteria. The cluster analysis is performed on the integrated database, which includes the data gleaned from the Watervalue research.

4.3.2 Correlation analysis, study of strength and direction of the correlations among potential explanatory variables

A considerable portion of the potential explanatory variables does not show normal distribution, therefore, in the case of the correlation matrix, I used the Spearman rho value as the basis to present the strength of correlations. I looked at the relationship, extent and direction of potential explanatory variables with the OPK/person, as well as at the strength of correlations with each other of potential independent variables.

The results of the study of variables, the correlation coefficients are shown in the correlation matrix, the relations of which for the OPK/person are shown in Tables 5-8 of Annex 3. My goal is to reveal which explanatory variables are in close relationship with the values of the OPK/person, to ensure that the regression model includes variables that meet statistical and professional considerations.

Explanatory variables ($0.7 \leq rho < 1$) in a strong positive correlation (see Table 5.) determine to a significant and determining extent, the per capita Aggregate Replacement Cost (OPK/person) indicator during the lifecycle studied.

There are five explanatory variables in the given Spearman rho value range, and they are related to the OPK/person indicator in the following order by strength):

- Annual depreciation – OÉCSI (HUF/person/year) calculated for the total replacement value established upon asset valuation.

- Total replacement value - OPÉ/person (HUF/person) the cost value per capita excluding VAT established upon asset valuation for the one-off replacement of the water utility system.
- Annual depreciation applicable - OÉCS2 (HUF/person/year) for the replacement value as asset value adjusted by obsolescence.
- Total asset value - OVÉ/person (HUF/person) value per capita excluding VAT adjusted by the obsolescence determined upon asset valuation of the one-off replacement cost of all water utilities.
- Per capita pipeline length (water-wastewater) (rm/person) sum of drinking water and wastewater pipeline length of the given settlement, based on the number of inhabitants, calculated per capita.

Of the variables in a strong relationship, four are indicators stemming from the replacement value established upon the asset valuation of the infrastructure, their different explanatory strength, though, highlights the differences in the expected lifetime (recurring replacement needs during the entire lifecycle) and in the state of obsolescence of infrastructure elements, as well as the differences by settlement, which have a strong influence on the replacement costs incurred during the entire lifecycle.

The only significant, non-value-linked (i.e., replacement value) explanatory factor, with a strong impact on the per capita total replacement costs is the per capita pipeline length, which was present already, in the form of a reference, in the literature review. None of the other factors has a strong explanatory power, either positive or negative.

Explanatory variables (0.2≤rho<0.7) in a medium positive correlation (see Table 6.), again in an order by strength, are the following:

- Per capita replacement cost incurred between 0-15 years - OPK15 (HUF/person/15 years)
- Per capita water-sewerage tariff total (HUF/person/m^3)
- Annual per capita total tariff payment (HUF/person/year)
- The per capita replacement cost incurred between 0-15 years (OPK15) correlates with the Top-heaviness indicator (opk15/opk35) highlighted. As has been shown earlier, although top-heaviness is also seen elsewhere, this indicator tends to be higher in smaller settlements, so coupled with the higher per capita pipeline length characteristic there, it results in in a medium positive relation. Water and sewerage charges per cubic meter, and

the per capita fee payment influenced by water consumption but also related to the tariffs, is higher in smaller settlements.

Explanatory variables (-0.7≤rho<-0.2) in a medium negative correlation (see Table 7.), again in an order by strength, are the following:

- Number of inhabitants
- Amount of personal income tax base (HUF 1000)
- Number of dwellings connected to the drinking water network, total - 2018
- Number of dwellings connected to the sewerage network (units) - 2018

In the latter chart, the negative direction is due to the higher variables in the larger settlements, and the trend is the reverse in terms of the direction of the OPK/person values, which are higher for smaller settlements….

Explanatory variables (0<rho<0.2) in a weak positive correlation (see Table 8.), which determine the per capita replacement costs to a lesser extent (weak relation), in an order by strength, are the following:

- Settlement density by county (pcs/100 km^2)
- Average price of used residential property sold (million HUF /property) - 2018
- Volume of water supplied per capita (m^3) - 2018
- Volume of (household) wastewater per capita discharged to public utility sewerage network (m^3) – 2018

Based on the preliminary results, according to my professional opinion and intuition, per capita pipeline length (water-wastewater) (rm/person) is the key independent predictor of the OPK/capita variable, with the single largest influence on its amount. The following sections of the study focus on the real predictors of the OPK/capita indicator for the estimated value and relations of the relationship among the variables, using linear regression calculation.

4.3.3 Linear regression (key relations defining the value of OPK/capita)

I have removed from the analysis potential explanatory variables where the correlation coefficient is 0.3 or less. In cases, where I thought it professionally justified, weak correlation values were also left in the analysis (see consistency index). I have removed two variables from the explanatory variables with a correlation coefficient of ≥0,81 (they cannot be regarded as variables independent from each other).

As has been established in the course of the correlation analysis, the independent explanatory variable with the highest Spearman rho correlation value, per capita pipeline length assumed the highest Unstandardized Coefficients value as well (see Table 9, Annex 3.). The strength of the relationship gained in the course of the analysis is 0.967 among the variables examined (square of the correlation coefficient), which proves the high explanatory power of independent variables studied and the predictive capacity of independent variables over dependent variables. Using the data of settlements within several different size groups, based on the model, I received results within 5-10% accuracy for the per capita total replacement cost values (OPK).

At the same time, it must be noted that the wide-ranging application of the model is hindered by the fact that some of the variables used in the model rely upon data generated through the asset valuation, thus it cannot be run without carrying out the asset valuation, important from a number of other perspectives, too. Further simplification of the model, while keeping the predictive capacity, calls for the introduction of the specific unit costs of the object forming the basis of the valuation (pipeline sections, etc.), which could form the subject matter of further analyses and research.

4.3.4 Cluster analysis

Hypothesis No. 5: *communities living in smaller and larger settlements are aware of the significant differences in the costs of municipal water and wastewater services that depend on the size of the settlement. Furthermore, they also perceive the need to upgrade infrastructure, and on the one hand they need it, and on the other hand they are willing to compensate for it, as part in the spirit of solidarity within society*.

In the absence of similar research covering a wide range of topics conducted in past years, I included my questions aimed at measuring the solidarity attitude in the focus group research titled “HWA - WATER VALUE - Water in Households, Perception of Water Supply and Wastewater Treatment” and in a survey based on a sample of 5,000 people, and I took data from the database generated in the course of the study (MASZESZ, 2020) into my analyses.

The compilation of the large sample questionnaire was preceded by exploratory qualitative research consisting of two focus group discussions.

Based on the results of the qualitative research, it can be stated that society perceives the difference in water tariffs according to settlement size; and the majority of respondents believed that the higher fee per cubic meter is unfair to those living in small settlements. In terms of expectations and willingness, the idea of a nationally uniform water tariff found a mixed reception.

The uniform water tariff, for the majority of participants was considered as an increase in price, especially for respondents in Budapest; for them, the increase could be justified only if it was accompanied by a change in quality.

Given the small number of participants in the qualitative research I evaluate my hypothesis Nr. 5. related to the sustainable water management and readiness for solidarity based on the results of the online questionnaire survey of 5,000 people.

The questions related to solidarity in the questionnaire focused on revealing of the two-directional (vertical and horizontal) solidarity-willingness:

Most water supply networks will reach the end of their 50-year life cycle in the coming years and need to be renovated. Which statement do you agree with?

It would be expedient to renovate them as soon as possible, even if this would require a financial contribution from everyone (86% of responses)

This question does not concern me at all and the solution should be left to the future generation, our children (14% of responses)

Would you support a nationally uniform water tariff, similar to electricity and gas supply?

Would support a nationally uniform water tariff (74% of responses)

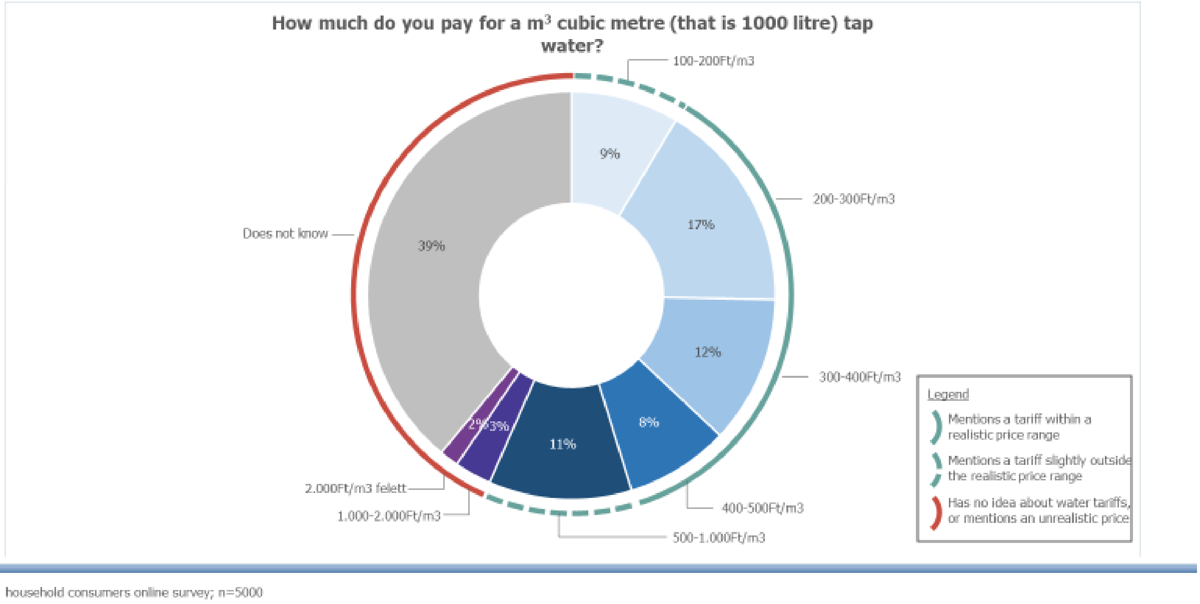
Would not support it (26% of responses)

In the light of the results, it can be stated that although in *the strongly familist Hungarian society… small community, family and exclusionary solidarity remains strong, or became even stronger*, (Takács, 2019) society has expressed solidarity in the issue of water management both vertically and horizontally.

The correctness of the hypothesis was further analysed based on the results of additional questions.

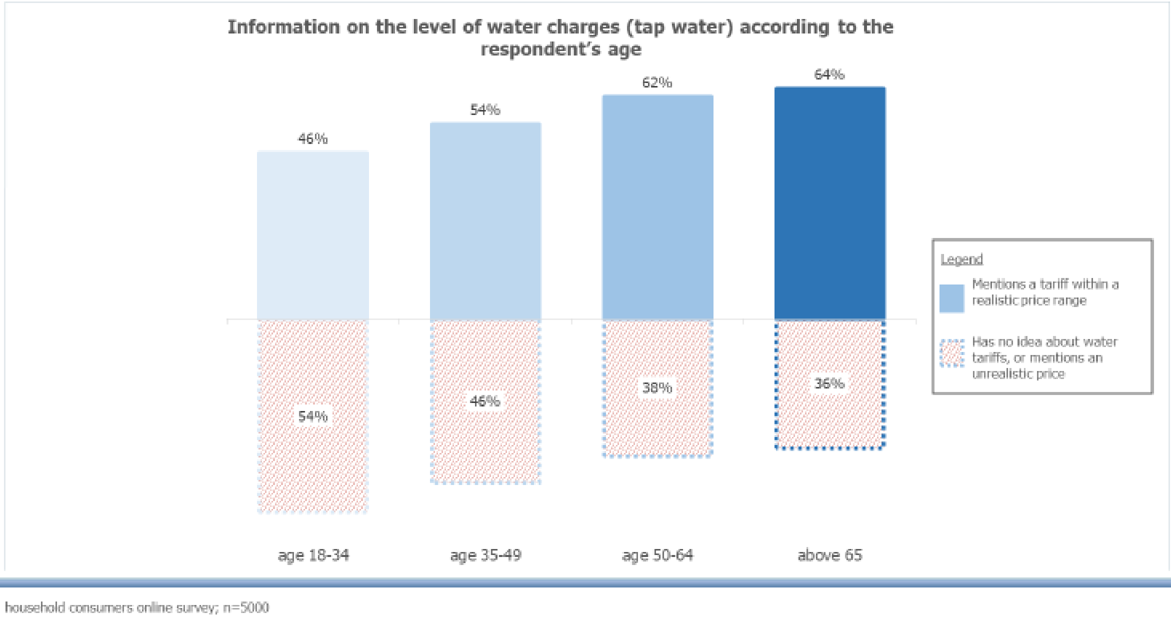
The research "HWA - WATER VALUE - Water in Households, Perception of Water Supply and Wastewater Treatment" also asked household consumers about the water tariff. The question was formulated as follows:

"*How much do you pay for one m^3 (cubic meter, or 1000 litres) of tap water? Please disregard sewerage and sanitation charges*."



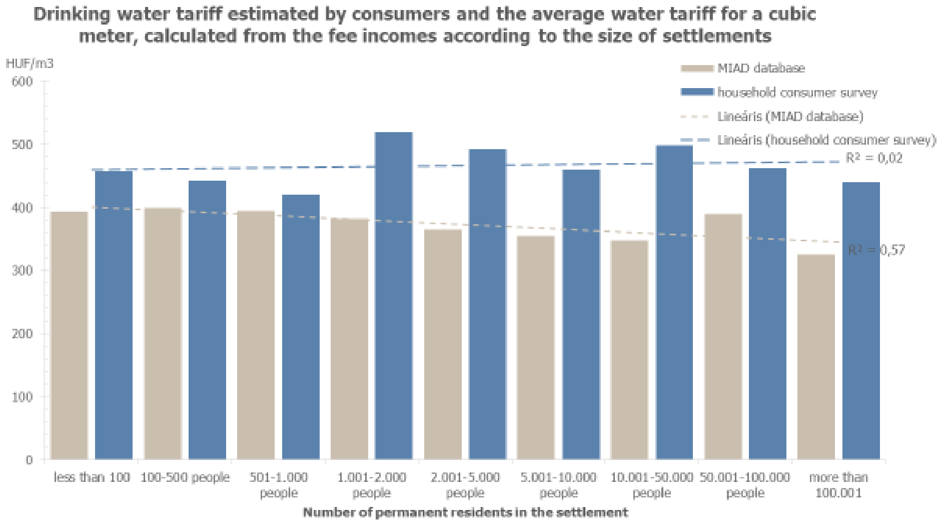
24. FIGURE: MASZESZ - WATER VALUE - WATER IN HOUSEHOLDS, PERCEPTION OF WATER SUPPLY AND WASTEWATER TREATMENT SURVEY – WATER TARIFF

It is clear that a significant proportion (44%) of consumers has no specific knowledge about tap water tariffs. Surprisingly, awareness is less dependent on the consumer's level of education, but rather on age and, to some extent, the person's place of residence or financial situation. 54% of the youngest age group (under the age of 34) are unaware of the tap water tariff or guess a completely unrealistic figure, while among the over 50 age group, the proportion of those with deficient information is 36-38%.



25. FIGURE: WATER VALUE - WATER IN HOUSEHOLDS, PERCEPTION OF WATER SUPPLY AND WASTEWATER TREATMENT SURVEY – INFORMATION OF THE POPULATION ON THE LEVEL OF WATER CHARGES (TAP WATER)

As for the statement in the hypothesis, namely that consumers would be aware of the significant differences in water tariffs according to the size of settlements, it has clearly been refuted by the survey. While it is quite clear from the examination of the settlements included in the MIAD (Multipurpose Infrastructure Assessment Database, Hungarian abbreviation: TIKA) database that the water tariff per cubic meter is higher in settlements with a smaller population, in the household consumer survey, the opposite correlation can be observed: those living in the smallest villages estimated, on average, the lowest water tariffs, while those living in settlements with a population over 1,000 rated the water fees they pay higher.



household consumers online survey; n=5000 and MIAD database HUF/per capita /m3

26. FIGURE: WATER VALUE - HOUSEHOLD WATER, PERCEPTION OF WATER SUPPLY, WASTEWATER TREATMENT SURVEY – AVERAGE WATER TARIFF FOR A CUBIC METER INCLUDED IN THE MIAD DATABASE, CALCULATED BY SETTLEMENT AND DRINKING WATER TARIFF ESTIMATED BY THE POPULATION IN THE HOUSEHOLD CONSUMER SURVEY

As for the attitude of the population towards water supply, the research examined a number of questions about what people think about wastewater and water supply. It is clear that only a very small segment is not at all concerned with the smooth and high-quality supply of water and wastewater services. Looking at the answers to the questions "*How concerned are you that the drinking water supply infrastructure will become obsolete without modernization and that pipe bursts will become more common?*", it is striking that 29% of the respondents consider themselves "very worried" about it and another 27% "worried" rated on a 5-point scale.

In order to make the results easier to manage, I combined the questions measuring involvement and concern related to water supply and sewage disposal into a single variable, based on clustering. The following variables were included in the k-means clustering:

How worried are you about the following statements:

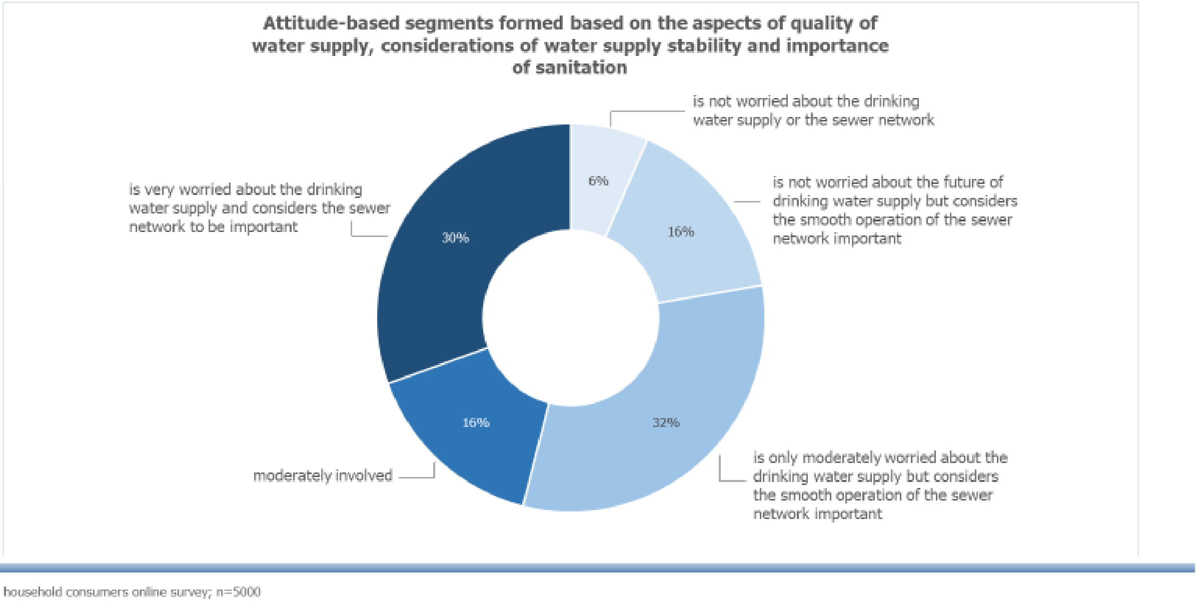
- Hungarian water resources are declining.
- Hungarian water resources are being damaged by pollution.
- the quality of Hungarian piped drinking water is deteriorating.
- the quality of Hungarian water supply is deteriorating, the water supply is stagnating and there are supply outages.

- piped drinking water supply infrastructure becomes obsolete without modernization and pipe ruptures become frequent

How important do you consider the following aspects in relation to sanitation? Please rate the previous considerations one by one. Please evaluate similarly to the 5-point school grading. Give 1 if the statement is not important to you at all, and 5 if it is very important:

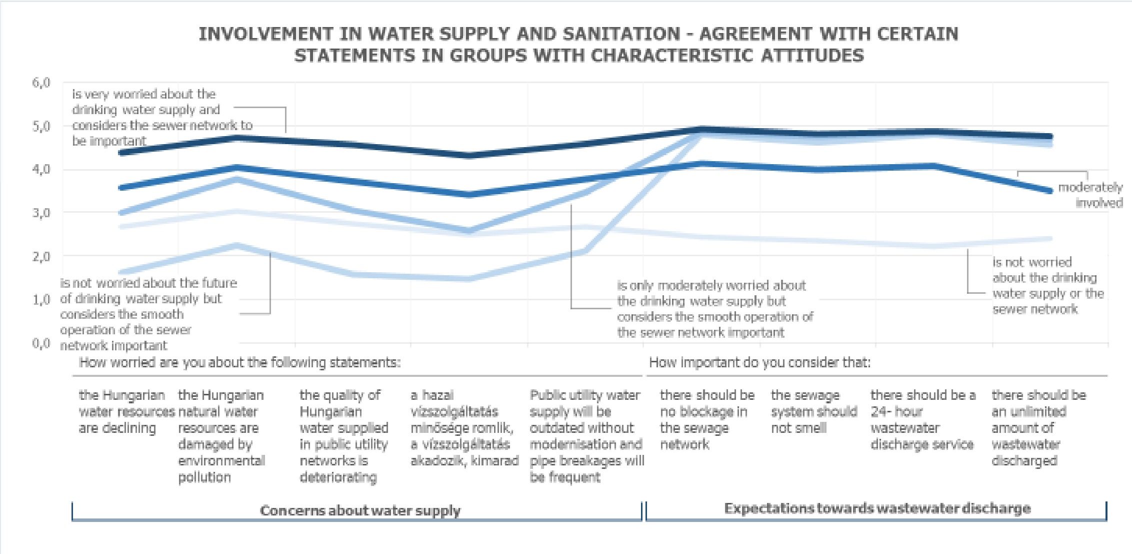
- there should be no pipe blockages
- 24-hour sanitation
- to have an unlimited amount of drainage

The result of the clustering is the following 5 clusters:



27. FIGURE: INVOLVEMENT IN WASTEWATER AND WATER SUPPLY - GROUPS BASED ON CHARACTERISTIC ATTITUDE

As seen above, a significant segment of society, every third person, attaches great importance to the issue of both drinking water and wastewater supply and is particularly concerned about the future security of water supply. Merely 6% of the population is not worried about the future of drinking water supply and does not consider the smooth operation of the sewer network to be particularly important. In addition to the moderately involved group, the two segments are more interesting that clearly separated the aspects of the drinking water supply and sanitation: what they have in common is that both segments consider the smooth operation of the sewer network important, but they are less concerned about the drinking water supply. The most significant group, 32%, are those who are concerned, albeit moderately, about drinking water supply security. The smaller group, 16%, seems to be concerned only with sewage disposal, and are not worried about water quality and the continuity of drinking water supply.

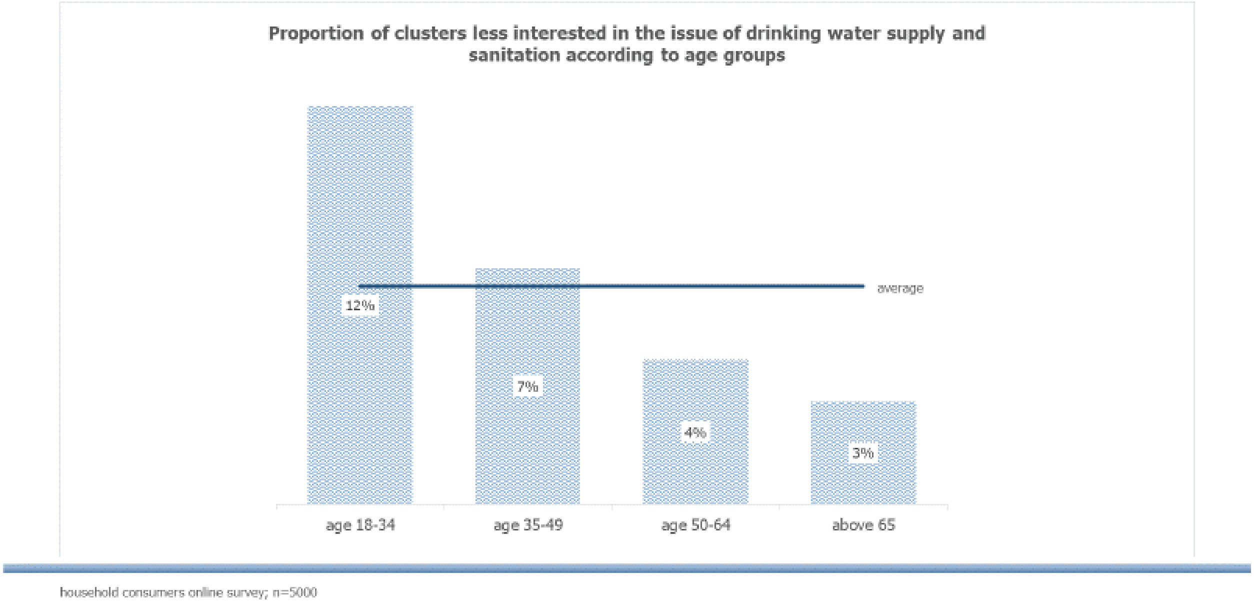


household consumers online survey; n=5000

28. FIGURE: INVOLVEMENT IN WATER SUPPLY AND SANITATION - AGREEMENT WITH CERTAIN STATEMENTS IN GROUPS WITH CHARACTERISTIC ATTITUDES

The smaller the settlement, the more likely it is to in the cluster of “those who are very concerned about drinking water supply and also consider sanitation to be very important”. This relationship is inversely proportional to household per capita income. Although one might think that this can be explained by the income of people living in certain types of settlements, it is also true within the same type of settlement that those with higher incomes are much less likely to belong to the group who consider the issue of water and sanitation to be particularly important and a cause for concern. For example, among the inhabitants of villages that make up the majority of settlements, only 20% of those in the top income quintile, and 38% of those in the bottom quintile based on per capita household income, belong to this particularly involved segment.

The importance of more intensive awareness-raising communication targeting young people is underlined not only by their lack of knowledge but also by the fact that the group with the least sensitivity to drinking water supply and sanitation is strongly over-represented within the 18-34 age group:



29. FIGURE: INVOLVEMENT IN WATER SUPPLY AND SANITATION - PROPORTION OF LESS SENSITIVE CLUSTERS ACCORDING TO AGE GROUPS FOR DRINKING WATER SUPPLY AND SANITATION

Almost regardless of one's level of concern about the security of water and wastewater supply, there is a broad consensus that ageing water networks should be upgraded as soon as possible. In my research, I examined vertical solidarity willingness based on the following question:

"*Most water networks will reach the end of their 50-year life cycle in the coming years and need to be renovated". Which statement do you agree with?*

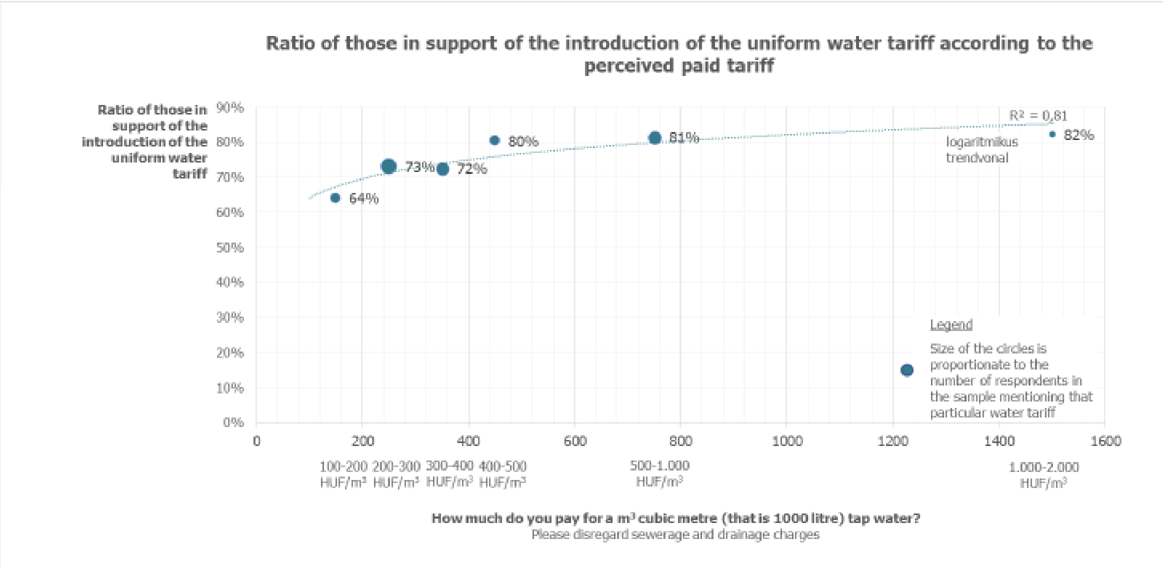
1. it would be advisable to upgrade these water networks as soon as possible, even if this would require a financial contribution from everyone;

2. I am not concerned about the issue at all and leave the solution to the next generation, my children

The vast majority of respondents, 86%, were in favour of modernization as soon as possible, even with the necessary financial contributions. For each of the clusters presented above, this proportion was above 80%, except for the segment that did not care at all about the drinking water and wastewater networks, but even among this small indifferent group, the proportion of those who did not tolerate delaying network reconstructions was 69%.

As for the other part of my hypothesis, namely, horizontal solidarity, and the introduction of uniform water tariffs, the answers point in the same direction in this area as well. In my research, I examined horizontal solidarity willingness based on the following question „*If you were aware* *that in smaller settlements, ie settlements with a few hundred or a few thousand people, the water supply costs up to 10 times as much as in larger settlements, would you support a nationally uniform water tariff, similar to electricity and gas supply?".* **74% of the respondents** would **support a uniform national water tariff,** similar to electricity and gas supply**.**

What is perhaps surprising is that support for a uniform water tariff is completely independent of the respondent's level of education and income. At the same time, the level of water fees paid by an individual has an impact on their support for the introduction of a uniform water tariff. Less surprisingly, with the increase in the water fee paid, the attractivity of the idea of a nationally uniform water tariff increases:

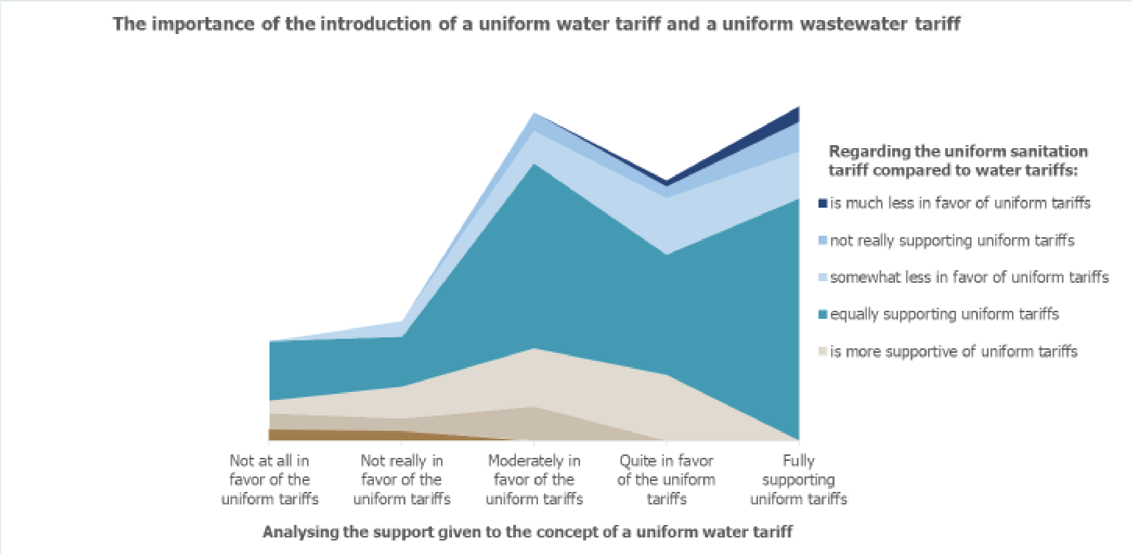


household consumers online survey; n=5000

30. FIGURE: INVOLVEMENT IN WATER SUPPLY AND SANITATION – RATIO OF THOSE IN SUPPORT OF THE INTRODUCTION OF THE UNIFORM WATER TARIFF

Although the figure does not show the answers of the respondents who could not recall the amount of water fee they pay, an average of 74% of them also supports the uniform water tariff. I also omitted from the figure 1.5% of respondents who claim to pay over HUF 2,000 for a cubic meter of tap water (excluding sewerage and drainage charges), which is quite an unlikely value; the confusion in the thinking of this group is indicated by the fact that, despite the estimated extremely high fee, 64% would support the uniform water tariff. Therefore, I decided to filter out this "noise" from the above analysis.

In addition to analysing the support given to the concept of a uniform water tariff, I also examined the importance attached to the introduction of a uniform water tariff separately from the importance attached to a uniform wastewater charge. These do not differ significantly from each other, although there are more differentiated response patterns at the individual level. 57% of the respondents consider a uniform water tariff to be just as important as a uniform wastewater fee, 20% consider the introduction of a uniform water tariff to be more important, and 22% would prefer the unification of the wastewater fee. However, the majority of them, 15%, consider the uniform wastewater fees to be only slightly more important than the elimination of the significant differences between the settlements in the current drinking water tariffs.

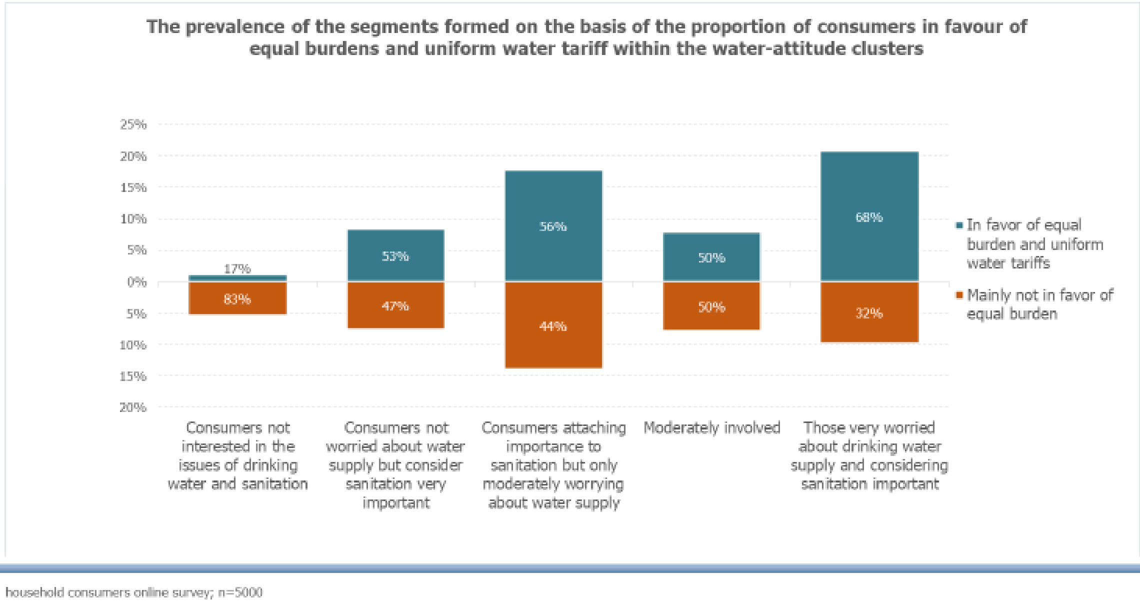


household consumers online survey; n=5000

31. FIGURE: INVOLVEMENT IN WATER SUPPLY AND SANITATION – THE IMPORTANCE OF THE INTRODUCTION OF A UNIFORM WATER TARIFF AND A UNIFORM WASTEWATER TARIFF BEYOND GENERALLY SUPPORTING THE UNIFORM WATER TARIFF CONCEPT

Examining the three questions presented above together, I formed a “supporters of equal burden” cluster, which divided the respondents into two groups based on their attitude towards uniform water tariff and sanitary charges: those in favour of solidarity and uniform water tariff accounted for 56% of the sample, and consumers less in favour of solidarity accounted for 44%.

Women, the over 50 age group, those with primary school education and those in the lowest income quintile on the basis of their net monthly per capita income are over-represented among those supporting the introduction of equal burden-bearing and uniform water tariff, as well as those living in smaller rural towns and villages with a population between 1000 and 5000, those living in Northern Hungary, especially in Nógrád county, and those living in Southern Transdanubia and Zala county. Concerning segments formed on the basis of concerns about the future security of water supply and attitudes towards intact sanitation, it is clear that those who are concerned about drinking water supply and also consider sanitation to be very important tend to support the introduction of a unified national water and sewage tariff, while those who do not attach importance to the issue of either drinking water or sewerage are much less in favour of a uniform water and wastewater tariff.

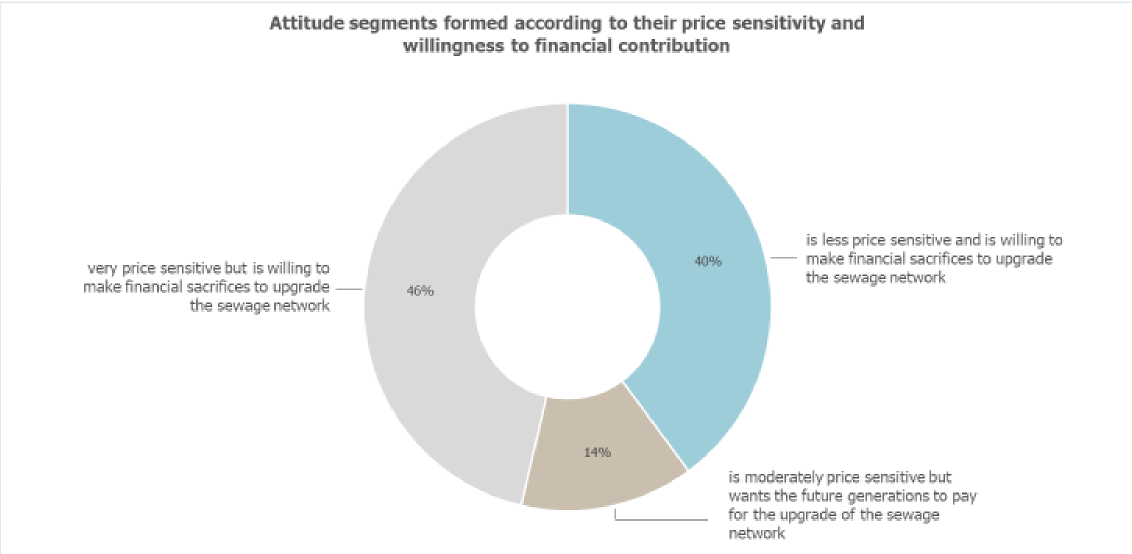


32. FIGURE: INVOLVEMENT IN WATER SUPPLY AND SANITATION – PROPORTION OF CONSUMERS IN FAVOUR OF EQUAL BURDENS AND THOSE LESS IN SUPPORT OF IT WITHIN THE CLUSTER OF SUPPORTERS OF EQUAL BURDENS AND UNIFORM WATER TARIFF

I also examined the attitude towards a uniform tariff structure in the context of the consumers' price sensitivity and willingness for financial sacrifice.

In the research, I also examined, in relation to both wastewater and drinking water, how important it is for people not to have a price increase of water or wastewater. In this regard, more than half of the respondents clearly stated that they would consider it very important (a value of 5 on a 5-point scale) to keep prices unchanged. I considered them to be price-sensitive, while at the other end of the scale, the 2% group who do not worry about the future changes in water and sewerage tariffs are not price-sensitive at all; the responses in between were categorised according to the level of price sensitivity. I also analysed this in comparison with per capita incomes: since the two variables showed a very significant correlation, and the lowest-income segment was clearly over-represented among those most rejecting the fee increase, this variable can be considered as an indicator of price sensitivity. However, it is important to see that this kind of price sensitivity does not necessarily mean a deprived life situation: even among those in the top income quintile, 36% are considered to be particularly price-sensitive - which is not a negligible ratio, even considering that the proportion of the most price-sensitive group within the bottom income quintile is 60%.

By using these two price sensitivity variables together with the previously-presented variable (which divides the population into two groups: those who consider the modernization of the network urgent, even at the cost of personal financial sacrifice, and those who consider the reconstruction of the network the task of future generations), based on the already applied k-means clustering, the following 3 clusters were created:



household consumers online survey; n=5000

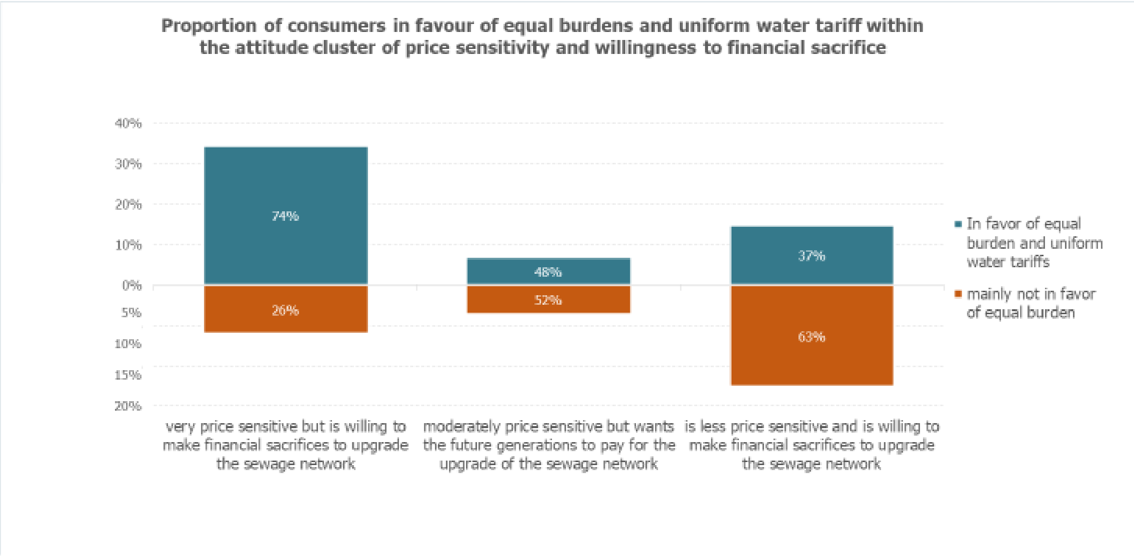
33. FIGURE: INVOLVEMENT IN WATER SUPPLY AND SANITATION – PROPORTION OF GROUPS FORMED ACCORDING TO THEIR PRICE SENSITIVITY AND WILLINGNESS TO FINANCIAL CONTRIBUTION

The highest segment identified on the basis of the cluster analysis, which includes 46% of the adult population, would not easily accept a fee increase, but would in principle contribute to a network reconstruction if they knew that drinking water networks would reach the end of their life cycle in the coming years. Within this significant segment, those who can be considered financially deprived represent 18% (they are in the lowest or lower-middle segment based on their per capita household income, real estate assets, level of education). They are the ones who, on the one hand, are likely to find it difficult to bear any additional charges, both in terms of their attitude and their financial resources, and, on the other hand, it is highly questionable whether they could actually contribute financially to a network renovation. Although the remaining 28% are likely to be able to tolerate a fee increase, they would still find it difficult to accept it, and they are thus less expected to support this. For them, perhaps, the importance of network modernisation is justifiable and linked to that, a tariff element can be accepted.

The group of consumers that is likely to be supportive of the water network reconstruction program, which may include a fee increase, is the 40% segment of those who, in addition to being willing to make a financial sacrifice for network upgrades, appear to be less price sensitive. 15% of them belong to the upper-middle or upper segment based on their income, real estate and education, thus, they can be considered as a support base, as they have the soundest financial means and, at the same time, a positive attitude.

In this 15% group, men, those under 50, and graduates are over-represented - precisely those social groups that are less supportive of the introduction of uniform water tariffs.

Overall, the less price-sensitive segment, which is willing to make financial sacrifices to renovate the network, has a lower number of supporters of the concept of nationally uniform water tariffs than the very price-sensitive group, which, in terms of proportion and absolute multiplicity, the segment of proponents of uniform fees is double.



household consumers online survey; n=5000

34. FIGURE: INVOLVEMENT IN WATER SUPPLY AND SANITATION – PROPORTION OF CONSUMERS IN FAVOUR OF EQUAL BURDENS AND UNIFORM WATER TARIFF WITHIN THE ATTITUDE CLUSTER OF PRICE SENSITIVITY AND WILLINGNESS TO FINANCIAL SACRIFICE

In summary, in connection with the statements formulated in my hypothesis, it can be stated that consumers are quite unaware of the level of water charges, and especially of the significant fee differences according to settlement size. At the same time, the concept of a nationally uniform water tariff would be quite widely supported, and not surprisingly even more so among those who, to the best of their knowledge, currently pay a higher water charge (above HUF 400 / m^3). The primary motivation behind the support for a uniform water tariff is not so much solidarity, but cost savings resulting from uniform tariffs (meaning lower for them). However, in addition to primary material interests, there is a dimension to which consumers can relate and through which intergenerational solidarity can be encouraged. 86% of the adult population supports the modernization of the water network as soon as possible, even if it requires financial sacrifices from all, and the proportion of those who would leave this burden to future generations is negligible. In addition, 15% of them are of high social status and are less price-sensitive, so it is to be hoped that they will not only support it in principle but would also contribute financially to these necessary investments.

In the next and final phase of the analysis, my aim was to create a common ground between the results identified in the household consumer survey and the settlement-geographical and water utility network operational data included in the MIAD database and to interpret them together.
Since the former is a research database resulting from an individual sampling procedure, while the basic units of the MIAD database are settlements, the condition for bringing the two databases to a uniform level was to first obtain settlement-level data from the household consumer survey data. First of all, I defined the variables that I wanted to include in the settlement-level database of MIAD, and for which data input and transformation from the individual level to the settlement level was a realistic option. These were the following variables:

Variables describing status - income

- average monthly net household income per capita
- income quintiles based on monthly net household income per capita
- income segments based on per capita income and subjective well-being
- segments formed on the basis of the estimated value of a residential property by category and its relative value within its category
- income segments based on per capita income and subjective well-being; gaps in responses are estimated on the basis of real estate value and educational attainment variables

Variables describing the willingness to material sacrifice related to water

- sensitivity to price increases of water
- sensitivity to the increase in wastewater charges
- making financial sacrifices for the renovation of water supply networks versus passing on the burden of network renovation to future generations
- Cluster of sensitivities related to price increases of water and wastewater charges and financial burdens undertaken for network development
- the importance of introducing a single water tariff
- support for a nationally uniform water tariff, similar to electricity and gas supply
- Attitude cluster related to water and wastewater public load bearing

Variables describing material sacrifices related to water supply

- Attitude-based segments formed on the basis of concerns about drinking water supply, as well as about its quality and stability and the importance of sanitation

Variables describing water consumption

- segments formed on the basis of the average monthly total water consumption of the household

I refer to these variables as key variables, which are contained in the MIAD database with data input described below.

Based on the household consumer survey, I calculated the average values of each key variable for each settlement or category of settlement. Thus, for example, if according to the 7 interviews conducted in Abony, 1 person was very price sensitive, 4 were quite price sensitive and 2 were moderately price sensitive in relation to water tariffs, then, based on the distribution of the answers, the average value of 2, which indicates a rather price-sensitive group, was added to the settlement of Abony. This, of course, meant a loss of information in the sense that data reflecting the diversity of the people living in the settlement and the standard deviation of the answers were lost as a result. At the same time, MIAD is a settlement-level database, so it naturally disregards the diversity of the settlement's consumers in terms of other aspects of water consumption as well. The aim of this analysis was to identify some pattern among the various settlements, and the variance between the settlements was not, or only minimally, worsened by the selected method.

As far as data input is concerned, as a first step, I filtered out from the household consumer survey database the settlements where the interviewees lived and are also included in the MIAD database. Of the 714 settlements, 297 were also included in the household consumer survey. Within this, the coverage of county seats was 100% and that of towns 88%, however, of the 607 villages and micro villages included in the MIAD database, interviews were conducted in only 202 settlements in the framework of the online survey, so only 33% of the villages are covered. Within this, going downwards based on the settlements' number of residents, the number of settlements included both in the household consumer survey sample and in the MIAD database was decreasing.

Based on the 1242 interviews conducted in the above-mentioned 297 settlements included in the MIAD database, the average value of the specific key variables of the given settlement was assigned to each settlement. I rounded these averages to an integer, so that by taking the original categorical values of the variables, they can be allocated to the rows of settlements in the MIAD database in the form of new variables.

In the next step, values had to be assigned to these variables for those settlements in the MIAD database that were not included in the household consumer survey. The settlement-specific variables included in both databases were used as a basis: the 7 geographical regions, the counties, the settlement types, and the 9 settlement categories created on the basis of the number of permanent residents living in the settlement. I took the complete matrix of these (19 counties x 3 settlement types x 9 size categories = 513 cells) and I assigned to each cell the averages calculated for the key variables related to settlements in the same county, with the same settlement type and same settlement size category. In the case of 389 settlements out of the 417 not included in the household consumer survey, I was able to identify at least one settlement in the household consumer survey that is located in the same county, belongs to the same settlement type and settlement size category. In the case of the remaining 28 settlements, I took as a basis the settlements in the same settlement category (villages) of the same county, the size of the settlement closest to the settlement size category in the MIAD database. (Most of these were villages in Nógrád county with less than 500 inhabitants, instead of which I was forced to select settlements with a population larger by a few hundred residents). All this ensured that I could use the answers of the people living in the most similar settlements for settlements included in the MIAD database, and I assigned the averages of their answers to each settlement in the MIAD database.

As a result of the data input, a database was created in which, in addition to the existing indicators concerning consumption, fees, condition and depreciation for all 714 settlements, information on consumers' attitudes and price sensitivities related to water supply are also available (at least at the level of estimates).

After the data input, the first step was to perform the data input test by examining the extent to which the settlement-level income data in the original MIAD database calculated from the personal income tax revenue data correlate with the income data input from the household consumer survey. Although there was only partial correspondence between the specific income categories of the two variables (for example, in the top fifth of the settlements included in the MIAD database, calculated on the basis of PIT income per capita, there were plenty of settlements that were ranked only in the middle fifth on the basis of the average monthly net household income per capita calculated on the basis of household consumer survey), there was a significant relationship between the two variables (Asymptotic Significance - based on Pearson's chi-square test: .000). I also examined the per capita personal income base in the MIAD database, calculated on the basis of personal income tax returns, within the income quintiles calculated on the basis of the household consumer survey. The relationship between the two variables is extremely strong also when examining the relationship in this way, (ANOVA test, 000 level showed a significant relationship, r-square value was 046, eta-square value was 066) moving up one increment in the income quintiles, except for the top quintile, here the PIT base values were higher:

5. TABLE: COMPARISON OF SETTLEMENT-LEVEL INCOME DATA CALCULATED FROM PIT INCOME DATA INCLUDED IN THE MIAD DATABASE WITH INCOME DATA INPUT FROM THE HOUSEHOLD CONSUMER SURVEY

Income quintiles based on household incomes stated in the household consumer survey	**Monthly PIT base per taxpayer based on the MIAD database**	
lowest income quintile	HUF 166,327	
lower-middle income quintile	HUF 185,897	
middle income quintile	HUF 195,600	
upper-middle income quintile	HUF 198,783	
top income quintile	HUF 194,312	

The expected value of the top quintile would in principle be around HUF 215,000 based on a linear regression calculation. There can be several explanations for the far-higher value of the top income quintile: on the one hand, PIT revenues do not necessarily fully reflect entrepreneurial income, which in turn may be part of a variable based on answers to a self-reported income question, and on the other hand, it may be the result of more frequent income concealment in the top income segment. However, the examination of this issue is not the subject of the present dissertation.

In spite of the above, I considered the integration of the household consumer survey data into the MIAD database to be sufficiently reliable on the basis of both the applied methodology and the test based on the income data presented above.

The purpose of the analysis of the database thus integrated, which will be presented in the next phase, was to be able to set up a segmentation between the settlements, which can help me to more effectively identify the groups of settlements where the financial resources necessary for the replacement and reconstruction of the water utility network can potentially be covered by involving additional resources financed by consumers, and those settlement segments where, even if possible additional charges are expected to meet the disapproval of the population, other potential additional sources can be identified (e.g. higher fees for public institutions), and finally, I can point to those groups of settlements where the situation is really critical, as there is no potential additional source for network development locally.

As a method of analysis, I used clustering in this case again, which is a suitable statistical method to create homogeneous groups of settlements within the clusters, but at the same time, the established settlement clusters differ most significantly from each other.

First, the variables included in the cluster analysis are presented, and then the created clusters.

Since one of the main objectives of the analysis was to identify the potential shortfall in the material resources needed for network reconstructions, I formed a variable that describes this potential deficit.
I examined the replacement cost ratio of each settlement cluster. For this, I used the MIAD database 'annual fee payment per person (HUF / year / person) divided by the variable Replacement Costs (OPK) - RC / person (HUF / person / year)'. It is important to emphasize at this point that the Replacement Costs in the MIAD database are demands and not actual expenditure. Furthermore, I also analysed that in the case that 7.5% of the annual fee payments per capita is considered to be the average replacement cost in service fees, (Depreciation, asset usage fee, replacement and development ratio described by the previously quoted literature, the study commissioned by the Infrastructure Association; (Vékony, 2018)) which is shown as a real expense, then how this relates to the annual replacement cost needs of the same settlement cluster. I then examined the same with an expense ratio proportional to 80% of fee income (the value ratio estimated in Chapter 1.2 based in part on previous literature data), and finally with an expense ratio of 94%. I calculated using a cost ratio of 94%, because as it will be demonstrated later, this cost ratio would result in a zero replacement balance on average in all the settlements in the sample: **if the current fee payments are considered to be unchanged, 94% of the fee payments would need to be set aside to cover replacement costs in order for the system to be self-financing in**

the long run. Even so, there would be a fair number of municipalities where the funding balance of the system would be strongly negative at the local level, with local contributions not covering the long-term renewal costs.

From this amount that could theoretically be spent on asset replacement, I deducted the value of the need for replacement per capita, and I considered the resulting difference to be a relative surplus, or (unfortunately in the majority of cases) a **deficit**.

I also prepared the same variable in the form of quotients and absolute values, where I divided the 7.5-80-94% share of the annual per capita fee payment by the annual replacement value per capita. This variable also expresses the extent of the payment deficit compared to the estimated level, but not in absolute HUF value, but in percentage form.

From both continuous variables, I formed a categorical variable that divides the settlements into 5 roughly equal groups, which I categorized as extremely low, low, medium low, medium, relatively high replacement cost share
In the database, I named these two variables 'eves_dijbefizbol_7.5-80-94pct_potlasi_ertek_perfo_kat5' and 'eves_dijbefiz_7.5-80-94pct_per potlasi_ertek_perfo_kat5'.

I also formed a categorical variable from the **average quality indicator**, consistently using the same principle during the analysis, dividing the sample into 5 equal parts. The resulting variable, named 'atlagos_allagmutato_kat5' in the database, thus designated the lowest quintile of the settlements with the worst water utility network, the lower-middle, middle, upper-middle quintile, and the top fifth with the least aged network.

Based on the "**top-heaviness" indicators**, I also created two categorical variables that divide the settlements into 5 categories with nearly equal numbers of settlements. Based on the variable named in the database 'fejnehez_potlasi_ktg_elso15ev_per_utolso35ev_ivoviz_kat5', one-fifth of the settlements where the need for replacement is most urgent in the field of drinking water network can be clearly identified. (the top-heaviness indicator in their case was above 1,161, but also, the 20% of settlements that are least expected to require significant investments in the drinking water network in the coming 15 years (among them the top-heaviness indicator calculated for the drinking water network was below 0.028)

Similarly, the middle categories indicated settlements that could be described by the medium top-heaviness indicator. I applied the same methodology for the sewage network. In the database, the variable marked 'fejnehez_potlasi_ktg_elso15ev_per_utolso35ev_szennyviz_kat5' identified the fifth of the settlements where the need for replacement is the least urgent (top-heaviness indicator is below 0.05), also settlements in the intermediate categories were identified, as well as the 20% of settlements where investment needs will appear relatively soon (settlements with a top-heaviness indicator above 0.742).

In addition to the quality of the network, I also included a calculated variable in the cluster analysis that describes the structure of the network, classifying the settlements into 5 categories based on the length of the pipeline per consumer. Municipalities where the **per capita drinking water pipe** was less than 14.3 meters in length were ranked in the bottom quintile, while where this value was above 33.5 meters were ranked in the top fifth. Intermediate values, similar to the variables presented earlier, were included in the middle quintiles. This variable, named 'lead length_perfo_kat5' in the database, is a useful indicator of how densely there are consumers in a given settlement, which can also be seen as a variable that expresses cost-effectiveness.

In order to be able to describe the settlements not only in terms of the quality and structure of the network but also the amount of drinking water and wastewater supplied in the segmentation, I used the amount of all supplied drinking water in cubic meters. Since the amount of wastewater correlates strongly with the amount of drinking water provided in the given settlement, I decided to only include in the cluster analysis the variable describing the amount of drinking water supplied. In order to be able to manage the settlements belonging to the same service provider in my model, and to have a variable at service provider level that can be incorporated into my cluster analysis, I first aggregated the indicator 'amount of drinking water supplied' for **each service provider** (in the sample for all settlements served by the given service provider) and then divided the sample into groups based on the **total amount of drinking water calculated** for each service provider. As some of the larger providers serve a significant proportion of the settlements in the sample, the quintiles used in most cases would not have worked for the calculated variables aggregated to provider level, therefore, I decided to categorize the sample into three nearly-equal groups.

Among the variables describing the amount of consumption, I also intended to include a descriptive variable of the wastewater sector in the clustering. However, as the volume variable itself correlates to a large extent with the quantity of drinking water supplied, I abandoned the idea, because it would not have had significant added explanatory value. Instead, I incorporated another calculated variable that, in addition to using the wastewater volume variable as a starting point, reflects the internal structure of consumption in the households-public institutions dimension very well.

Within the settlement-level data on the amount of wastewater discharged, from the quotient of the data series on the amount of wastewater discharged by public institutions and the total amount of wastewater generated in the given settlement, I first calculated the proportion of public institutions within the amount of wastewater produced in the given settlement. Similar to the procedure applied in the case of drinking water, I aggregated this ratio variable to service provider level. Thus, I calculated the weight of public and industrial consumers within the wastewater sector for each service provider. I selected wastewater for this purpose partly due to the fact that the proportion of public sector consumers is more differentiated between settlements in the case of wastewater than in the case of drinking water. I considered the proportion of public institutions in consumption to be a key variable in my analysis partly because, because I was confident that this would identify settlements where, even if the possibilities of additional resources on the part of the households were limited, consumption of public institutions seemed to be more significant, and on this basis, consumer burdens could be passed on to public consumers to a greater extent. In the database, this indicator, which **describes the proportion of public institutions within the total amount of wastewater per service provider** is called 'public_wastewater_m3arany_personal_servers_kat3'. Similarly to the method applied for the amount of drinking water used, I divided the sample into roughly three equal groups of the settlements.

The next group of variables included in the cluster analysis were the geographical and demographic characteristics of the settlements.

Based on the original **county-level settlement density** variable in the MIAD database, I established a categorical variable, dividing the settlements into three groups of roughly equal numbers. The settlements in the lowest third were those that can be characterized as having fewer settlements within an area at the county level (maximum 3.9 settlements / 100 km2). The top third includes the more densely located settlements within a county (at least 4.9 settlements / 100 km2). I included this variable in the database as 'telepules_suruseg_permegye_kat3'.

Furthermore, another variable is included in the clustering that describes the density of settlements but at the service provider level that indicates the **number of settlements belonging to the service**

area of a given service provider and are also included in the sample. The variable in the database called ‘telepnum_perszolgaltato_kat3’ was formed based on the aggregated number of settlements at service provider level, and based on this variable, I created a categorical variable with 3 values, classifying the settlements into nearly three equal groups.

Furthermore, a variable describing the **number of residents** of the settlements is also included in the clustering, which I first transformed into a 4-value variable for the sake of simplification and better manageability: For groups with less than 500 inhabitants, 501-1,000 inhabitants, 1-2,000 inhabitants and over 2,000 inhabitants. I included this variable in the database as ‘colour_at_cat4’.

Among the variables included in the clustering, I included the categorical variable formed based on the **aggregate annual PIT base variable per capita of each settlement**, which I formed by transcoding the original variable in the MIAD database to quintiles. This is included in the database as ‘SZJA_alap_perev_perfo_kat5’.
Aggregated from the annual personal income tax per capita basic variable to service provider level, the **per capita personal income tax basic variable projected to the consumer base of each service provider** was calculated (in the database referred to as ‘SZJA_alap_perszolgaltato_kat3’), which provides information on the settlements in the area covered by the same service provider where the consumers with the highest income live among the settlements belonging to the same service provider. In other words, this variable helps to identify the service providers that, in the event of a possible tariff increase, can expect higher willingness to pay due to their higher-income consumer base, and service providers and the associated municipalities that would not tolerate a tariff increase or with great difficulty due to low consumer incomes.

Furthermore, I formed a categorical variable based on a variable included in the original MIAD database that shows the average **price of flats sold** in the given settlement, which also grouped the settlements into 5 equal segments, from settlements with very low-value properties (<3Mio HUF / apartment) to settlements with the highest average value properties (12Mio HUF </ apartment). This variable is called in the database ’hasznalt_lakasar_kat5’.

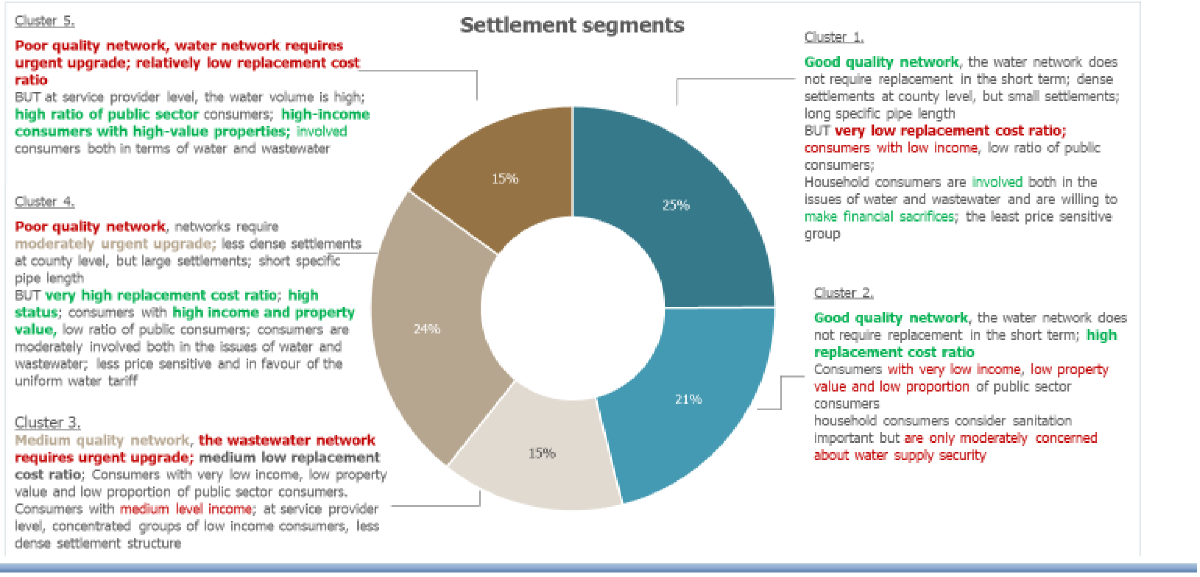
I also included a combined **status variable** input from the household consumer survey into the database as a variable characterizing the financial situation of people living in a given settlement. It was partly calculated based on the household income data per capita, or, where there was a lack of answers, the respondent’s estimated the value of his / her own property was calculated with, or where the respondent could not give a meaningful answer, I defined the status classifications based on the respondent's level of education. The variable is included in the database as ‘jovedelmi_status2’.

By definition, the analysis included the cluster segments identified in the course of the household consumer survey, which **describes the attitude related to the security of water supply and sewage disposal**. Since this was a nominal scale variable, first I converted it to dichotomous variables, where each variable was converted to a variable of 0-1, and all 5 clusters were given a separate variable. Thus, separate variables were given to the following segments: “those who care about drinking water and the sewerage network”, “those who are not worried about the supply of drinking water, but consider sewerage to be very important”, "Those who consider the issue of the sewerage network to be important but only moderately concerned about drinking water supply", "moderately involved" and finally "those who are very concerned about drinking water supply and also consider sewage disposal very important". I included them in the database as vizattitud_klaszter5_1, vizattitud_klaszter5_2, vizattitud_klaszter5_3, vizattitud_klaszter5_4, and vizattitud_klaszter5_5.

A 3-scale cluster variable measuring **price-sensitivity** is also included in the analysis, which divides consumers into the following segments: a segment that is very price-sensitive but willing to make financial sacrifices to renovate the network; moderately price-sensitive but passing on the financial burden of network reconstruction to future generations; a segment that is less price-sensitive and is willing to make financial sacrifices to renovate the network. This variable is listed in the database as ’arerzekenyseg_attitud_klaszter3’.

Finally, among the variables input from the household consumer research, **the variable expressing the attitude related to equal burden and the nationally uniform water fee** is included in the cluster analysis, which divides consumers (and thus, indirectly municipalities) into proponents of public burden-bearing and uniform water tariffs, and those generally opposing public burden-bearing and uniform water tariff. This variable is listed in the database as ’kozteherviseles_klaszter2’.

The final result of the clustering was a cluster dividing the settlements into 5 groups. The distribution of the settlement groups was as follows:



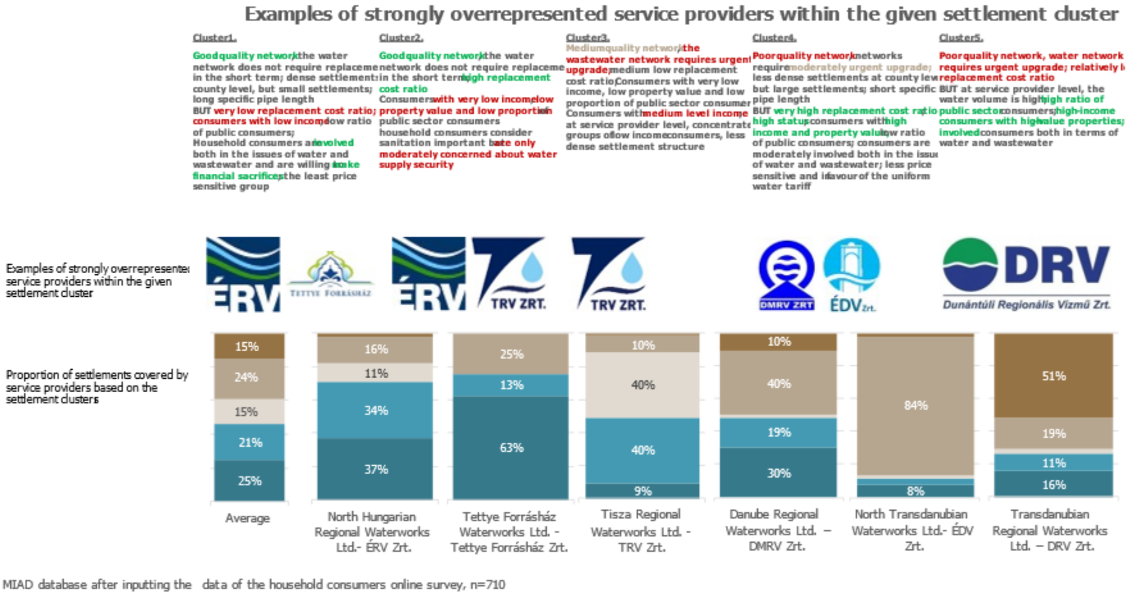
MIAD database after inputting the data of the household consumers online survey, n=710

35. FIGURE: FINAL RESULT OF CLUSTER ANALYSIS - A CLUSTER DIVIDING THE SETTLEMENTS INTO 5 GROUPS

The above settlement clusters show very strong differences in geographical, regional distribution. The two clusters with good condition networks (1st, 2nd) are strongly over-represented in Northern Hungary, and the 2nd cluster can also be characterized by a medium-level replacement cost share and it can also be found in the Northern Great Plain region. The settlement segment with a network in medium condition is most typical in the Northern Great Plain and the Southern Great Plain. Settlements with a network in poor condition and requiring relatively urgent modernization are overrepresented in Central Hungary and the Central Transdanubia region. Settlements with poor conditions and in urgent need of renovations of their drinking water networks are located in Transdanubia at an above-average proportion, especially in the Central Transdanubia region.

According to the types of settlements, the two groups with better conditions are small and micro villages, and the settlements with networks in poor condition requiring renovations with moderate urgency (described by a medium top-heaviness indicator) are mainly in towns.

Therefore, there is a strong correlation between the various settlement segments and the waterworks with urban and regional service areas. As there are several service providers in the sample that are only present in one municipality, Thus, in my analysis, I highlighted only those larger service providers for which, in addition to the statistically strong correlation between each settlement segment and the service provider (the adjusted residual value is above 2), the number of settlements belonging to the service provider in a given settlement segment was over 20, so of which I can make valid statements with greater certainty. I added Tettye Forrásház Zrt to the 5 regional service providers that meet these criteria, that, although serving a relatively small number of settlements, is a dominant service provider in Pécs.

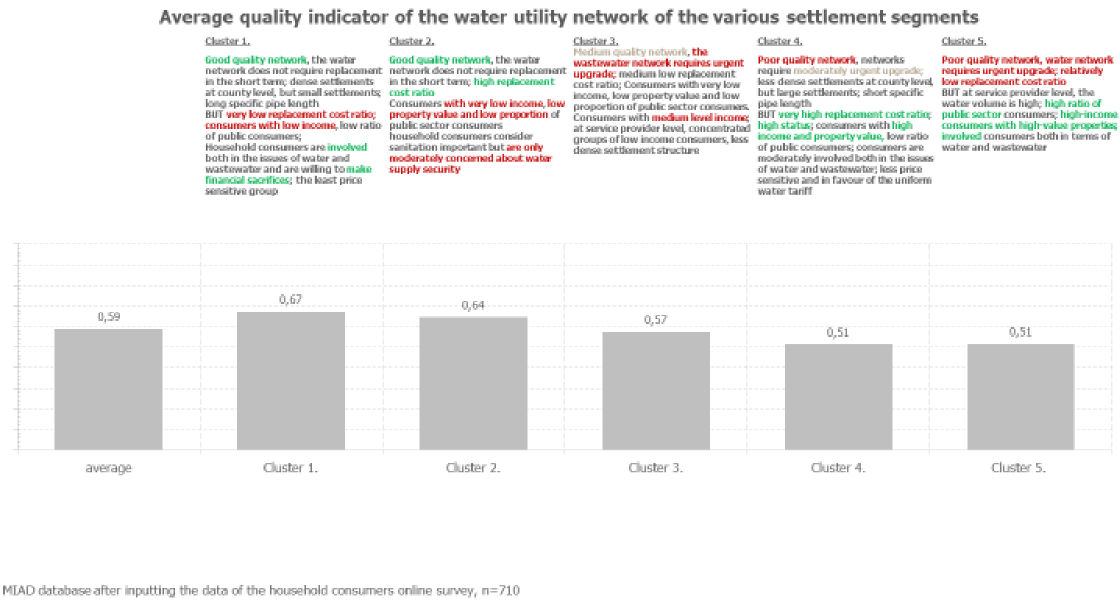


36. FIGURE: SETTLEMENT CLUSTERS IDENTIFIED IN THE SERVICE AREA OF THE MOST DISTINCTIVE SERVICE PROVIDERS

It can be clearly seen that even in the service area of the most distinctive service providers, almost all of the identified settlement clusters are represented; larger service providers cannot therefore be considered homogeneous in this respect. Consequently, if any business strategy were to be formulated at the level of service providers, it should be taken into account that although the above key service providers have dominant, characteristic settlement segments, a strategy optimized for a given settlement cluster may not be applicable for other settlements in the service area of the same service provider. However, the segmentation created may also be suitable to help some service providers formulate a relatively optimal guide, as evidenced by service provider-level characteristics.

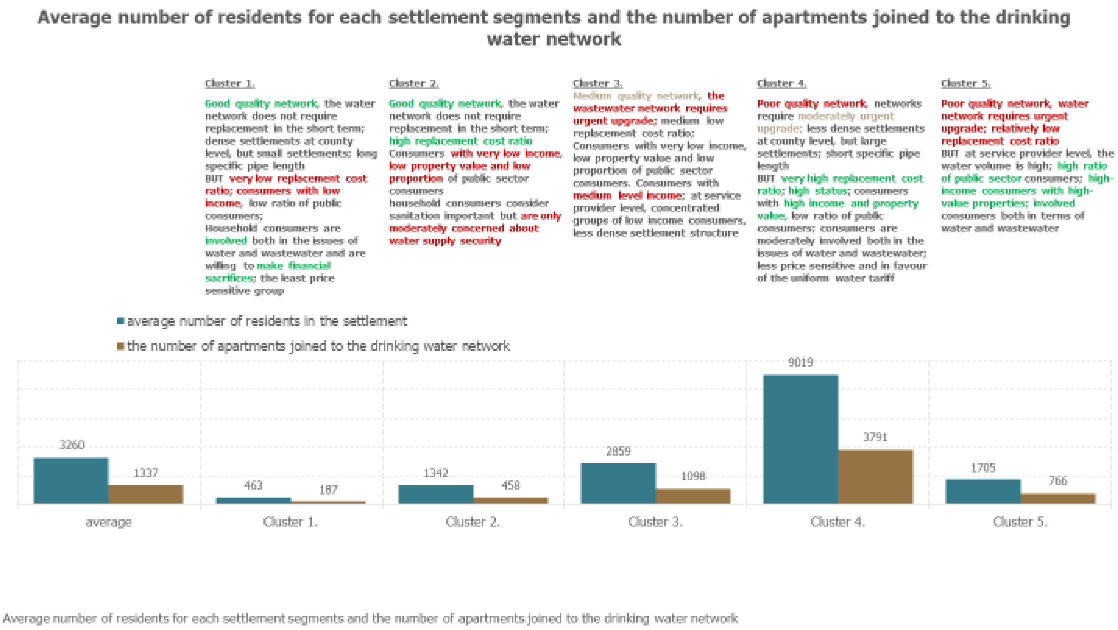
At the same time, it should be emphasized here that the public utility property to be replaced or developed is not owned by the service provider, and the replacement needs is greatly hindered by the fragmented ownership structure.

The average network quality of settlements belonging to the various settlement group is described with the average network quality index, which developed as follows in each cluster:



37. FIGURE: AVERAGE NETWORK QUALITY OF SETTLEMENTS IN EACH SETTLEMENT GROUP

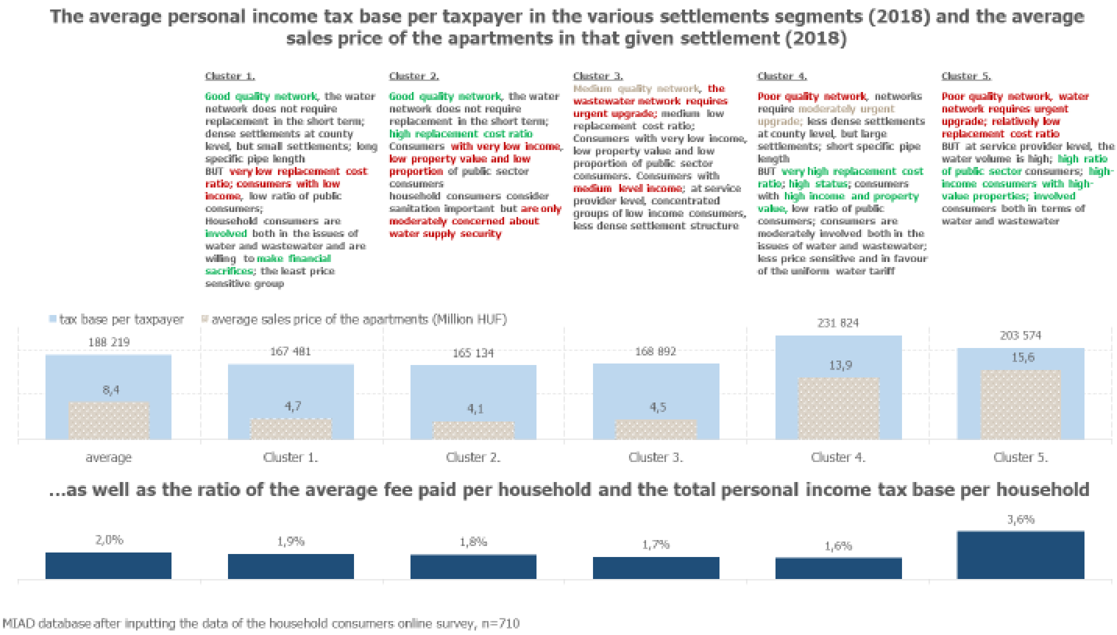
As for the size of the settlements allocated into the various settlement clusters, among the settlements in cluster 4 representing settlements with poor conditions and a network in need of semi-urgent modernization, are all the county seats in the sample, without exception, but towns are also over-represented in this segment, as well as the settlements in the agglomeration of Budapest were also typically included here. The other cluster of settlements in a dilapidated state, where the modernization of the drinking water network is expected to become due within the coming 15 years, typically includes holiday settlements around Lake Velence and Lake Balaton. Of course, many other settlements are included here, but this is a characteristic group within this cluster.



38. FIGURE: SIZE OF SETTLEMENTS ALLOCATED INTO THE VARIOUS SETTLEMENT CLUSTERS

Among the settlements in Cluster 1, with good conditions, but with a distinctly low replacement cost ratio, the villages and micro villages of Nógrád county and Baranya county should be highlighted as being over-represented within the cluster. Among the settlements included in cluster 2, which are typically in good condition with medium replacement costs share, the counties of Borsod-Abaúj-Zemplén and Nógrád, and especially the large number of villages and micro villages in Szabolcs-Szatmár-Bereg county are worth mentioning.

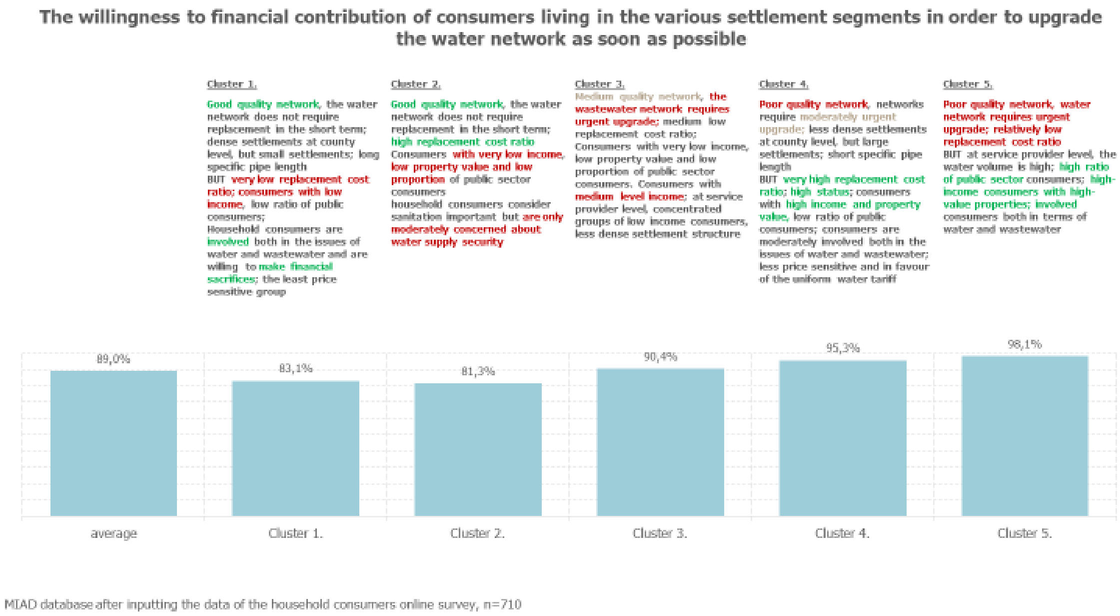
As for the household income situation of the individual settlement clusters, as mentioned in the description of the settlement clusters, clusters 4 and 5 with the worst infrastructure have the highest income populations. People living in settlements with an obsolete network with a moderate top heaviness indicator in cluster 4 have by far the highest incomes: the HUF 232,000 personal income tax base per taxpayer exceeds the average value of the sampled settlements by 22%. Consumers living in this settlement are not only considered to have a higher status on the basis of their monthly income, but are also wealthier on the basis of the value of their property. Comparing the water and wastewater tariff payments generated here to the incomes of the local residents, it is obvious that within this group, the ratio of water utility fee compared to the total income of households is the lowest among the 5 settlement clusters. Consequently, if there is room anywhere **to raise fees of household consumers, it is in these settlements**. Although the share of replacement costs in this group of municipalities is still relatively high (at least compared to the other settlements in the sample), additional fee payments could be appropriate due to the poor condition of the network, and although, due to the relatively high ratio of replacement costs, the tariffs might cover the network renewal in the long run, an increase in charges could bring forward these already necessary investments in the medium term in time.



39. FIGURE: RESIDENTIAL INCOME OF SETTLEMENT CLUSTERS

The other settlement segment, where the income of local residents is remarkably high, is settlement cluster 5, where the top-heaviness indicator of the drinking water network within the generally degraded infrastructure is far above average and thus requires urgent modernization, moreover, this is the group of settlements where the current moderately low replacement cost ratio would not provide coverage for network upgrades in the long run. Although, similarly to Cluster 4, the high income of residents would, in principle, allow for higher water charges, on the other hand, comparing the current fee payments to the households incomes, even with the current tariff, this group of settlements pays the highest water and wastewater fees in proportion to income by far. However, **what seems to be feasible in these settlements is to incorporate a fee element into the real estate-related taxes to finance the development costs of the water utility network**. This can be a tax levied on the sale or inheritance of real estate, it can be a real estate tax, or in the case of real estate (also) operating as a private tourism accommodation, it can even be imposed as part of the tourism tax. As it can be clearly seen that the value of residential real estate in these settlements is far above average, the additional revenue generated, even if it were a negligible annual % fee compared to the value of the property, could represent a significant additional source for service providers or to the owner municipalities or the state responsible for financing the replacements.

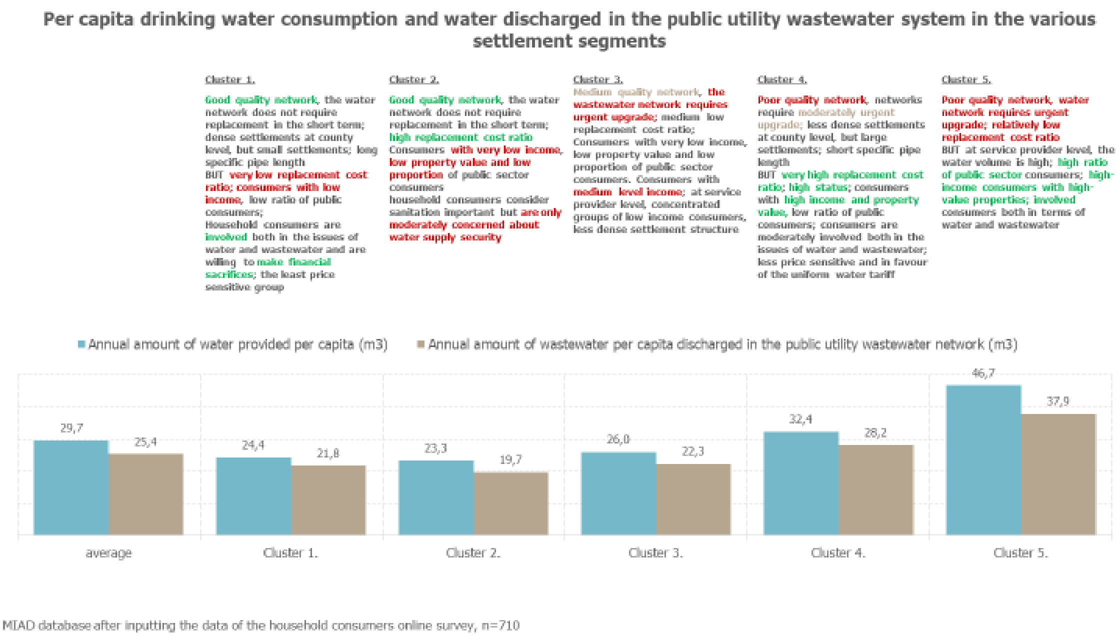
An increased tariff is further justified in the latter two settlement segments by the fact that these two segments had the highest proportion of consumers willing to make financial sacrifices in order to modernize the water supply network as soon as possible.



40. FIGURE: ADDITIONAL CONSUMER CHARGES IN THE SETTLEMENTS

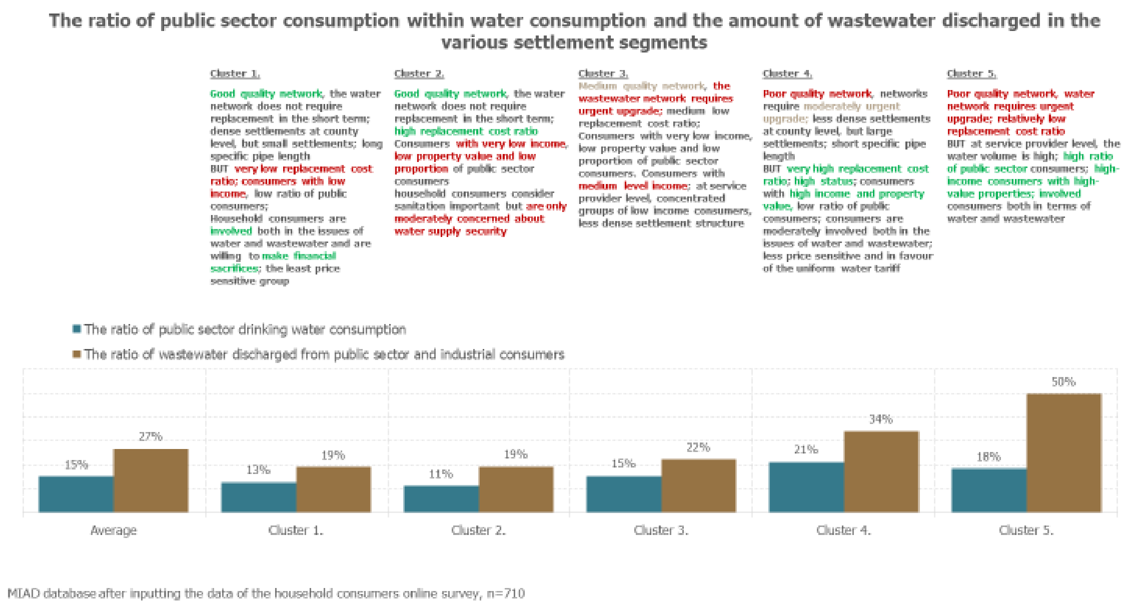
The absolute value of the indicator should be treated with caution, since, on the one hand, general idea of financial sacrifice was not associated with a specific amount in the survey, so its extent is unknown, and on the other hand, as in other interview surveys, respondents tend to respond normatively, while their actual behaviour would not necessary correspond with the willingness expressed in the interview. So I do not think that 98% of the local consumers really are willing to sacrifice money for a network upgrade, and I consider it even less likely that 81% of the population in the settlements with the least willingness to contribute financially to the development of water and sewage pipelines would actually do so. Nevertheless, this indicator seems to be a good tool to interpret it as a relative indicator to establish a ranking among the settlements, and based on this, a business strategy can best be built on the settlement clusters 4 and 5, where additional financial contribution can be requested from the population for network developments.

As for the water consumption and the amount of wastewater discharged in each settlement, the differences at the settlement level are mainly due to the size of the settlements and the number of people living there. I do not think that the in some cases significant differences among settlements regarding per capita consumption are due to the higher water consumption of the people living there (although atypical water consumption such as watering a larger garden or car washing may result in higher water consumption), I consider it more likely that the explanation may be due to a significant discrepancy between the registered permanent residents of these settlements and the number of temporary residents. It is no coincidence that the water consumption and wastewater volume per capita in cluster 5 is outstanding, where holiday villages and resort towns around Lake Balaton and Lake Velence are concentrated. The permanent population of these settlements is much smaller than the number of people staying there during the summer season and significantly increasing water consumption. In the case of these groups of settlements, an increase in the proportion of the tariff element expressing the availability of the service should be considered, as the aging of infrastructure and the cost of replacing it, as well as the additional costs of network water loss, occur independently of the amount consumed.



41. FIGURE: WATER CONSUMPTION AND WASTEWATER DISCHARGE IN SOME SETTLEMENTS

When examining the consumption of settlements, it is vital not to only examine household consumption, but public and industrial consumers must also be taken into account. Considering public institution consumers is particularly important not only because of the higher specific water and sewerage charges they pay, but also because, when it comes to the financing needs of water utility investments, with a limited fee burden on the population, due to the fragmentation of costs and the need for the principle of solidarity, greater involvement of public consumers in financing is certainly justified. The focus of my analysis at this point was to map, in which groups of settlements public and industrial consumers can be relied on as potential "cost bearers". To this end, within the quantitative variables of drinking water consumption and wastewater consumption (in cubic meters), I examined the proportion of drinking water consumed by public consumers within the total amount of drinking water used, and similarly, the proportion of wastewater discharged from public customers in a wastewater network within the total volume of wastewater. Thus, I obtained the public consumption rates for both sectors.

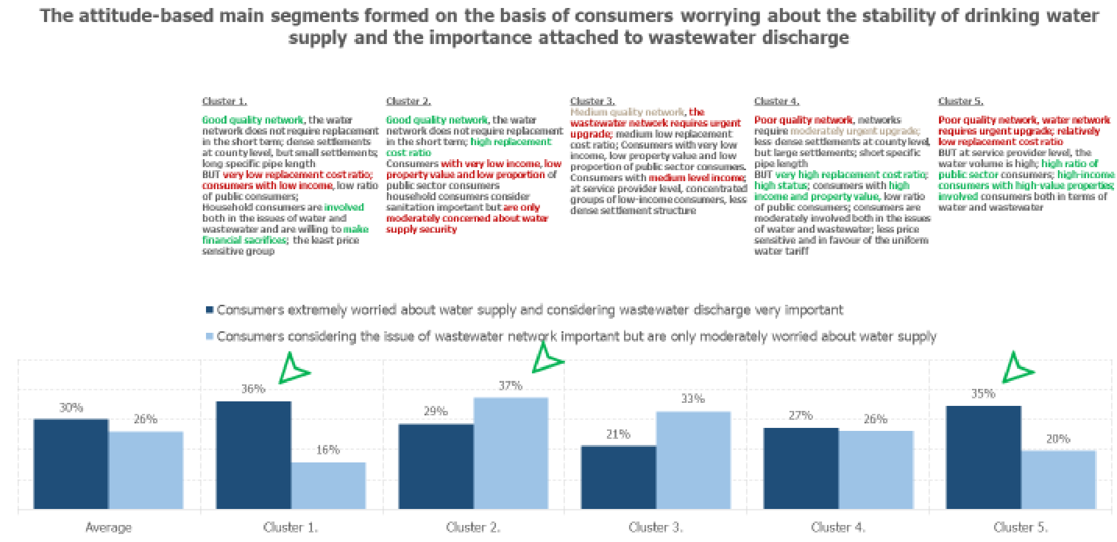


42. FIGURE: ANALYSIS OF THE CONSUMPTION OF SETTLEMENTS

The analysis revealed that the two groups of settlements with the most obsolete networks - especially cluster 5, where the replacement cost ratio is moderately low and the drinking water network would need to be modernized as soon as possible - have the highest share of public consumers in the amount of wastewater discharges, but the importance of public consumers in drinking water use is also above average. In this segment, therefore, one does not need to count on the population exclusively with regard to financing, but it is also worth relying on public and industrial consumers. The situation is similar in settlement segment 4, where the proportion of public consumers is above average simply because all of the county seats and a large number of towns in the sample were included in this cluster. Here, too, it is especially within the amount of wastewater discharged where the weight of public and industrial consumers is outstanding. In settlement groups 1-3 not only the incomes of the population are lower, but also the weight of public users is relatively moderate, so the limited solvency of the lower-income household consumers in these settlements cannot be compensated by the higher share in payments by local public consumers, or at least the weight of public consumers in consumption is not so great that a smaller surcharge on public consumers could in itself result in a more significant revenue mass due to the large number or large volume.

The settlements belonging to the settlement group of cluster 2 are the ones with a relatively good water utility network and where based on initial difficulty indicators the modernization tasks are also expected to take place further in time, and although the replacement cost ratio is moderate, settlement cluster 2 is in principle the least problematic or risky segment. The limitation here is that the people living here are the consumers with the lowest income, the proportion of public consumers is also low, and the involvement of consumers in the issue of water supply is below average, too. This means that the involvement of consumers would face obstacles in terms of attitude, income and also solvency.

Although the network in the settlements belonging to cluster 1 is also of relatively good quality, the share of replacement costs is extremely low, therefore the financial coverage of the future reconstruction of the network is rather questionable. Thus, although there are no problems here in the short run, much rather in the medium term, and the results show that in this segment it is more difficult to find financing for these than as it seemed in settlement clusters 4-5. However, the attitudes of the population of the settlements belonging to settlement cluster 1 towards the security of water supply and the stable operation of sewage drainage indicate that the people living here are quite involved in water issues and they are worried about the future of a stable, high-quality water supply. This higher level of involvement could in principle be built on, and an attempt could be made to involve them more in the financing of network developments in the longer term, even if it is just by a more modest increase in fees taking into account their more limited financial possibilities.

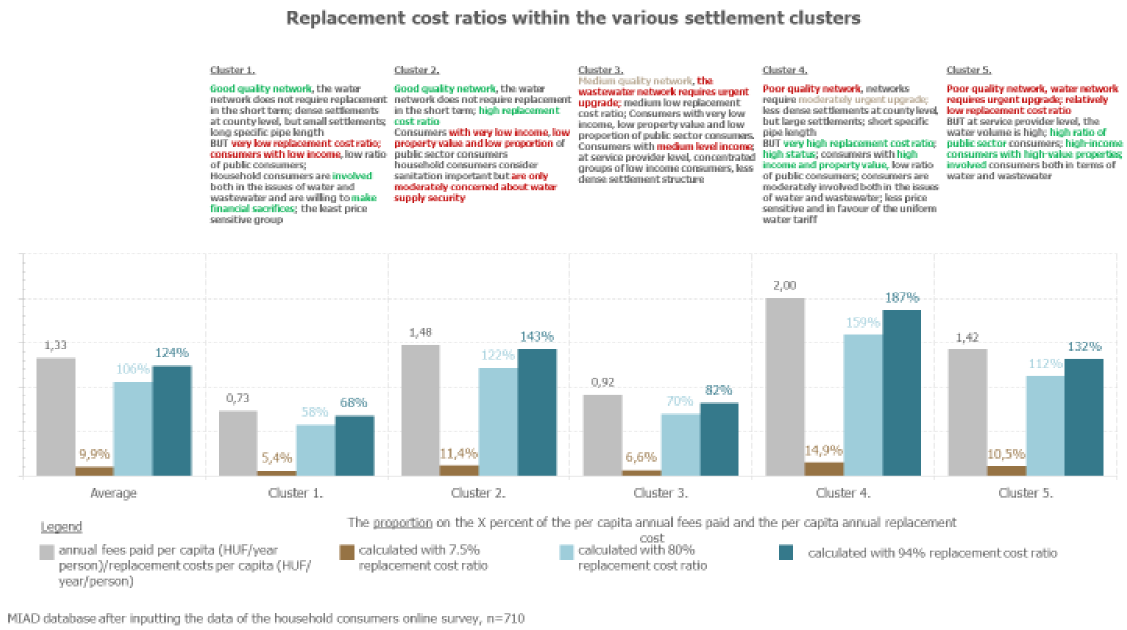


MIAD database after inputting the data of the household consumers online survey, n=710

43. FIGURE: ATTITUDES OF THE POPULATION OF SETTLEMENTS RELATED TO SECURITY OF THE WATER SUPPLY AND STABLE OPERATION OF SANITATION

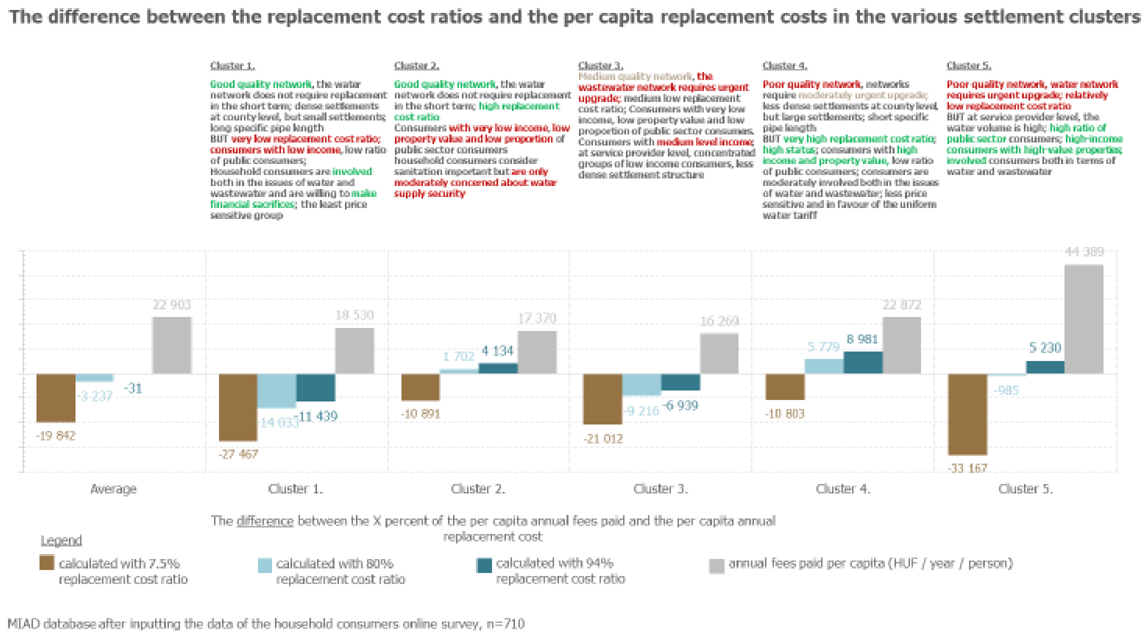
Even so, there would be a fair number of municipalities where the financing balance of the system would be strongly negative at the local level, and local contributions would not cover the long-term renewal costs even with this level.

Based on these, the following quotients were found for each cluster:



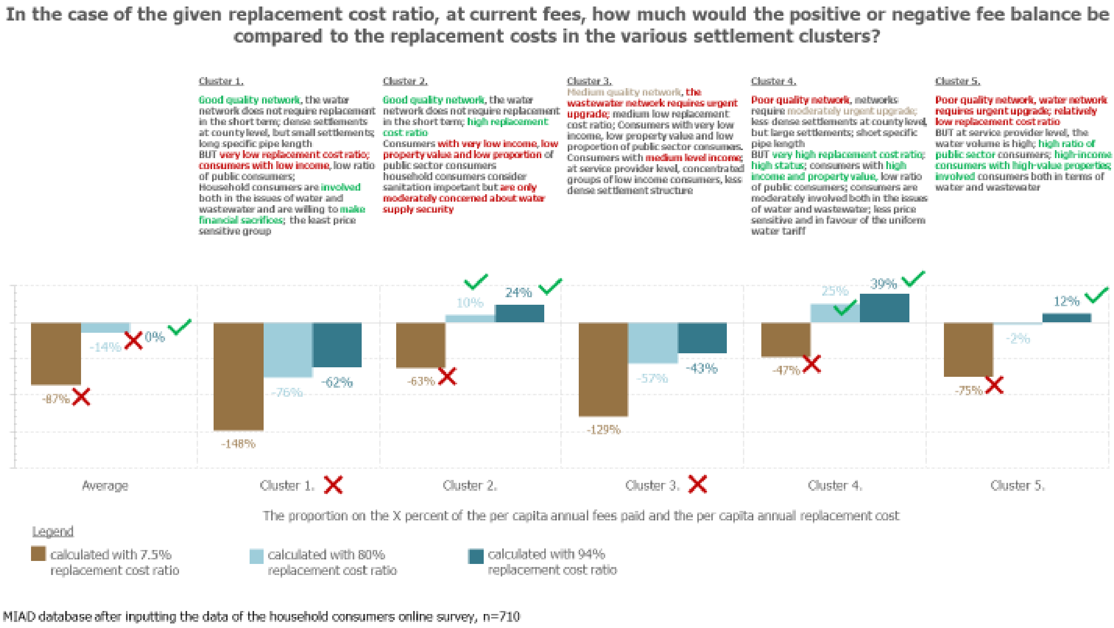
44. FIGURE: REPLACEMENT COST RATES OF SETTLEMENTS, FINANCING BALANCE OF SETTLEMENTS

If I look at how much the share deducted for replacement costs from the fee payments in the three examined scenarios lags behind or exceeds the annual replacement costs per capita of the settlements in the same settlement cluster, it is clear that in the case of a 7.5% replacement cost ratio all settlement clusters are overall unsustainable. In the case of the current annual average fee payment of HUF 22,903, the 7.5% replacement cost ratio results in a HUF 19,842 shortfall per capita compared to the replacement cost requirements. In contrast, a 94% replacement cost ratio would lead to a zero balance at the level of all settlements (-31 HUF / year / person)



45. FIGURE: REPLACEMENT COST RATIO PER CAPITA AND FINANCING BALANCE OF SETTLEMENTS

If I subtract the annual per capita replacement cost requirement of the settlements in the same settlement cluster from the replacement cost share of the annual fee payments per capita calculated in this way and examine this difference in proportion to the current annual fee payments per capita, I receive information on the balance of the replacement costs in each settlement cluster would be in the case of the analysed 3 different replacement cost ratios, assuming that the level of the current fee payments is unchanged.



46. FIGURE: BALANCE OF REPLACEMENT COSTS AT THE LEVEL OF CURRENT FEES

One can see that with an 80% replacement cost ratio, the balance of the settlements belonging to clusters 2 and 4 would already be clearly positive, i.e., the payments here would already finance on the long run the replacement costs incurred. However, as after the deduction of the 80% replacement funding, the remaining 20% of current payments would certainly not cover other ongoing costs (energy, maintenance, operation…), we cannot speak of a sustainable system for these municipalities at the current fee level either, but the problem is a relatively small in this case. If I take cluster 2. as an example, the average annual fee payment per capita there is 17,370 HUF. If I take the current average replacement cost ratio of 7.5% as a basis, and I consider that out of this HUF 17,370, HUF 1,303 builds currently a reserve for future replacements, and the remaining 92.5%, i.e., HUF 16,067 is spent on operating costs and service, and at the same time we see that an 80% replacement cost ratio would be needed to cover the cost of future replacements, which is HUF 13,895 (17,370 x 0.80), and I add this HUF 13,895 to the current operating costs of HUF 16,067, I will receive an annual fee of HUF 29,963 per capita. This value of nearly HUF 30,000 would mean a 72% fee increase per person in the annual fee. This is what would provide the coverage for future replacements.

In the case of the settlements of cluster 5, the budget would be slightly negative with an 80% replacement cost ratio (-2%), and it would clearly turn into a surplus with a 94% replacement cost ratio.

In the case of the settlements belonging to clusters 1 and 3, the situation is even more dramatic: even if 94% of the current fee payments were used for replacement, it would not cover the replacement costs, so if future renovations were to be financed from local revenues, it would only be possible by the multiplication of the current water charges.

The reality of filling the gaps in coverage in all clusters through fees is questionable, even though social research shows that 93% of respondents consider it important for public water supply to provide drinking water quality water. At the same time, we can see that a significant part of the population, 27%, or about 2.5 million Hungarians, do not drink tap water at all. (MASZESZ, 2020b) This astonishing result is supported by a research report on the website of the Blue Planet Climate Protection Foundation, according to which this proportion reaches 47%!, meaning that nearly half of the total population does not hold their glass under the tap, unless it is for washing dishes.

"*Mineral water is more popular among people living in small towns and villages, but most of all it is popular with those who are dissatisfied with the quality of tap water. Tap water and mineral water also act as some sort of complements, with three-quarters of respondents choosing only one of these two drinks. 36 percent of the respondents drink mineral water but no tap water, and 39 percent drink tap water typically without consuming mineral water. Both drinks at the same time were mentioned by 14% of respondents, whereas 11% did not mention either.*" (FORSENSE, 2019) Perhaps it is worth adding here that based on the finding that: "*mineral water consumption in Hungary is extremely high in a European comparison, it exceeds 120 litres per capita per year".*(FORSENSE, 2019) it means that our total social expenditures on drinking and household water supply are already twice the fees paid for public water services examined in the previous studies. Knowledge of this circumstance provides a double justification for the implementation of the improvements: on the one hand, with the deterioration of the state of infrastructure, alternative expenditures continue to increase, and on the other hand, as conditions improve and consumer confidence and cost awareness increase, current drinking water consumption proportions may change in favour of tap water, also strengthening the safety and sustainability of domestic water supply, which accounts for 97% of primary public utility supply.

5. Summary and recommendations

1. The value of infrastructure replacement costs per capita, which serves as the basis for water utility services, is five times higher in the smallest settlements (HUF 52,871 / person / year) compared to the largest settlements (HUF 9,830 / person / year)
2. The average cost requirement (evenly distributed over time) for the maintenance and replacement of the water utility infrastructure (HUF 21,198 net / person / year) exceeds the current service fee revenues (HUF 22,892 gross / person / year with 27% VAT deducted: HUF 18,025) / person / year) and is almost 10 times higher than the current reconstruction expenditure. This situation is exacerbated by the fact that due to the age composition and technical condition of the water utility infrastructure, the distribution of replacement needs in time shows significant differences (top-heaviness indicator, 2-5 times the average distribution), which means an exceptionally high replacement requirement for drinking water supply systems in the next 15 years, in some settlement groups 40-100,000 HUF / person / year.
3. The time distribution of replacement requirements varies by sector and settlement group, in such a way that in smaller settlements they are more concentrated in time, with higher outstanding values beyond the average (in settlement groups 1-5, 25 times the average and for all Hungarian settlements, for 1,300 settlements, 20 times the average). This outstanding value indicator becomes more balanced in time and can be reduced under the twofold value, and thus become more manageable in fees by merging the cross-sectoral asset management and the regional management of the municipal asset management (regional consolidation of water utility systems).
4. Infrastructure replacement values are **NOT** reflected in tariffs. Although the service fees of smaller settlements are insignificantly higher than those of larger settlements, this difference is far from covering the replacement needs.
5. People living in small and large settlements realize the need for infrastructure renewal and to 86% they are in favour of their earliest possible modernisation, even if this required a financial contribution from everyone, and although they are not aware of the significant differences in the costs of municipal water and sanitation services depending on the size of the settlement, 74% are ready to compensate for it, to show solidarity and take on social participation.

Based on the above, in accordance with the strategic recommendations submitted by MASZESZ to the sectorial administration (MASZESZ, 2020a) I am making the following general findings and strategic recommendations that can be projected on all of the 3155 settlements:

- In order to fully assess the situation of the infrastructure forming the basis of the water utility service, the water utility property assessments not yet completed for the deadline of 31 December 2019 and prescribed by the Water Utilities Act (Parliament of Hungary, 2011a) must be performed as soon as possible
- The complete data set must be uploaded to the Integrated Public Utilities Database (IKVA) completed in 2019, and its proper professional operation, data processing, evaluation and maintenance, and ultimately the provision of data underpinning the asset and cost management strategy, must be ensured.
- During the Rolling Development Planning of the infrastructure (15-year long-term planning) the following points must be taken into account
    - a significant decrease in consumption in recent decades (more than 90% at extreme values, and more than 50% on average)
    - the methodological principles for lifecycle cost and variation analysis supporting the cost-effectiveness of asset and fee management (MASZESZ, 2011) (MASZESZ, 2016)
    - a system-level (regionalization, hydraulic modelling (decreasing diameters), water supply management, digital system management) approach to the development (renewal / replacement) of system components in critical condition
    - methodological development of the RDP design with a focus on cost-effectiveness, testing on a sample project if possible
    - the provision of development funds in line with the asset portfolio of HUF 5,000 billion with a replacement ratio of approximately HUF 10,000 billion and an average obsolescence ratio of 50%,
        - average replacement funding requirement is HUF 200 billion / year
        - average value retention funding requirement HUF 100 billion / year
- in order to maintain and develop the service provider's ability to satisfy the growing consumer and environmental protection expectations and needs, taking into account changes in climate, water regime and water quality the following elements need to be provided
    - asset value-based innovation funding insurance

- knowledge-based human resource management
- life cycle cost-based decision making
- horizontal solidarity maintaining small settlements
- vertical solidarity supporting the next generation
- strengthening the skills for social participation
    - strengthening water-value communication
    - raising awareness

6. Attachments

Appendix 1: The method of implementing Water Utility Asset Valuation

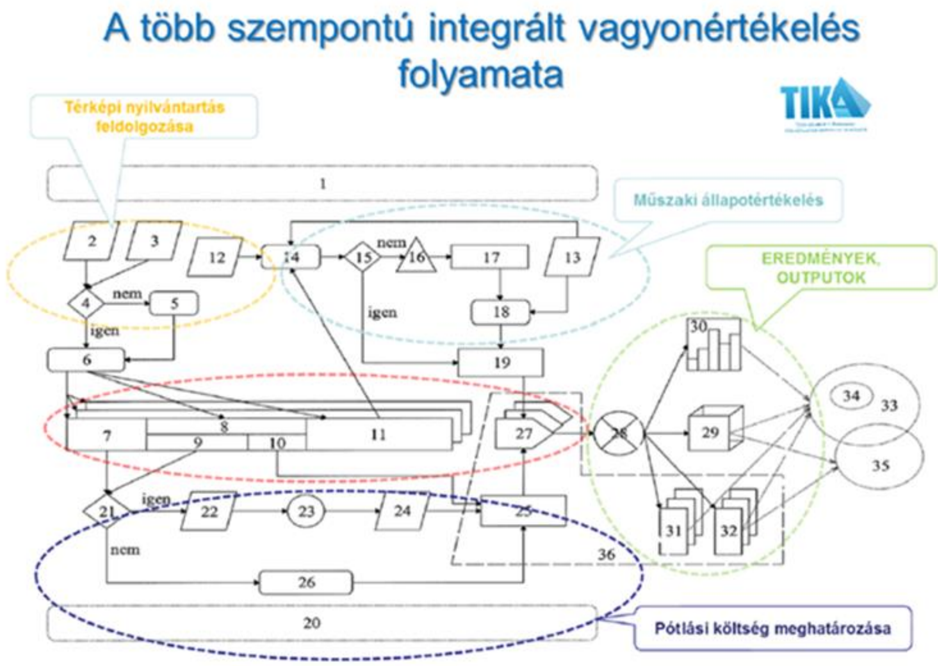
The method of implementing water utility asset valuation is prescribed by NFM Decree 24/2013. (V. 29.) on the rules for the asset valuation of water utilities and the data to be published by water utility service providers in the public interest) (NFM, 2013a).

According to the decree:

- *"The valuation of the water utility according to the Water Utility Services Act must be carried out in such a way that it provides a reliable starting point for sustainable and cost-effective operation, and the change in the value and technical condition of the assets of the water utility sector can be monitored and is documented."*
- *"The obsolescence-adjusted reproduction cost method should be used to value water utility assets."*
- *"The condition indicator of the water utility object must be determined between 0.1 and 1.0. The condition indicator shall be determined…. taking into account the year of construction and the life expectancy."*
- *"In the inventory of water utility assets, all elements of infrastructure, water utility objects must be listed broken down in the following structures: Groundwater abstraction,… Waterworks,… Water treatment facilities,… Drinking water network,… Water reservoirs,… Pressure boosters, (gravity) sewer, sewage pipes (force mains) …wastewater lifting plants,… Sewage treatment plant,… Individual wastewater treatment plant,… Semi-natural wastewater treatment plants,… Individual closed wastewater storage,… Individual water utility facilities: water utility elements not to be classified in the above types…, and all of them to be categorized according to: building, structure; machinery, equipment; control technology, energy supply."*
- *"Identification of the water utility object, in the case of point-like water utility objects, settlement, street name, house number or topographical number and, if available, EOV (Unified national projection) coordinates; in the case of a linear water utility object, per shaft or node, but at least by water utility object homogeneous according to material, diameter and year of construction: settlement, street name or topographical number and, if available, the EOV coordinates of the start and end points, their technical and conditional characteristics, replacement cost and asset value shall be determined in at least sufficient detail to support the cost of reproduction or replacement and to be suitable for the purpose of property valuation."*

- *In the case of the condition characteristics of the water utility object, the year of construction and commissioning, the expected service life and the condition index shall be recorded.*
- *"The replacement cost shall be determined per water utility object, indicating the specific and individual costs, supported by cost calculations. As the replacement cost, the lower value out of the reproduction cost and the replacement cost shall be taken into account."*
- *"The value of the water utility asset shall be determined per water utility object, based on the documented valuation characteristics of each water utility object, as the product of the replacement cost and the condition indicator of the water utility object."*(NFM, 2013b)

The process is illustrated by the flowchart that also provided the basis for the structure of the MIAD software. (Kovács, 2012)



Appendix 2.: List of MIAD flow chart reference symbols

1) Establishment of an inventory system, condition assessment and evaluation
2) Existing technical records
3) Existing accounting records
4) Decision: Are existing records adequate?
5) Digitalization of existing paper-based maps
6) Creating a structured, digital database broken down into object groups
7) Identification and name of object
8) Technical characteristics
9) Technical specifications
10) Technical quantitative characteristics
11) Condition characteristics, condition indicators
12) Existing condition assessment documentation
13) Operator experience
14) Evaluation of status information
15) Decision: Are condition characteristics, condition indicators adequate?
16) Designation of critical and representative sections, objects
17) On-site inspection, visual inspection and instrumental diagnostic examination (according to Standard EN 13508-2)
18) Determination of the time of the expected replacement
19) Corrected condition indicator
20) Estimation of reproduction cost
21) Decision: Can the object be typified?
22) Specific cost
23) Correction of specific cost
24) Corrected specific cost
25) Reproduction cost
26) Individual cost estimate
27) Asset value of object
28) Display of data supporting asset management, reconstruction planning, and accounting records
29) Total asset value
30) Forecast of annual reconstruction requirement

31) ÉCS-1 (annual depreciation derived from the cost of reproduction and the expected replacement time)
32) ÉCS-2 (annual depreciation of the asset value derived from the depreciation rate specified in the accounting policy)
33) Asset management
34) Reconstruction planning
35) Accounting records
36) Economic characteristics

Appendix 3: Correlation and Regression Tables

6. TABLE: CORRELATION TABLE, STRONG CORRELATION

Spearman's rho	Replacement costs per capita during the examined life cycle - OPK/per capita (HUF/per person/50yrs)
Pipe length per capita (water-sewage) (rm/ person)	.730**
Total replacement value - OPÉ/capita (HUF/person)	.917**
Total asset value - OVÉ/capita (HUF/person)	.840**
Annual depreciation - OÉCS1 (HUF/person/yr)	.971**
Annual eligible depreciation - OÉCS2 (HUF/person/yr)	.867**

7. TABLE: CORRELATION TABLE, MEDIUM POSITIVE CORRELATION

Spearman's rho	Replacement costs per capita during the examined life cycle - OPK/per capita (HUF/per person/50yrs
Residential water and sewer charges together (HUF/m^3) - 2019	.270**
Annual fee payment per person	.264**
Replacement cost between 0-15 yrs per person - OPK15 (HUF/person /15yrs)	.597**

8. TABLE: CORRELATION TABLE, MEDIUM NEGATIVE CORRELATION

Spearman's rho	Replacement costs per capita during the examined life cycle - OPK/per capita (HUF/per person/50yrs
Number of homes connected to the drinking water pipeline network, total - 2018	-.396**
Number of homes connected to the sewerage network (pc) - 2018	-.375**
Amount of personal income tax base (1000 HUF)	-.439**
Number of residents	-.479**

9. TABLE: CORRELATION TABLE, WEAK POSITIVE CORRELATION

Spearman's rho	Replacement costs per capita during the examined life cycle - OPK/per capita (HUF/per person/50yrs
County settlement density (pc/100 km^2)	,176**
The amount of water supplied to 1 person (m^3) - 2018	,166**
Amount of (domestic) wastewater discharged into the public wastewater collection network per capita (m^3) - 2018	,193**

10. TABLE: CORRELATIONS OF LINEAR REGRESSION, TABLE OF RESULTS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	Change Statistics: F Change	Change Statistics: df1	Change Statistics: df2	Change Statistics: Sig. F Change
1	,984[a]	0,967	0,967	157 808,613	0,967	1 897,529	11	702	0,000

a. Predictors: (Constant), Annual eligible depreciation - OÉCS2 (HUF/person/yr), Number of homes connected to the sewerage network (pc) - 2018, Residential water and sewer charges together (HUF/m^3) - 2019, average condition indicator = ové/opé, Amount of (domestic) wastewater discharged into the public wastewater collection network per capita (m^3) - 2018, Pipe length per capita (water-sewage) (rm/ person), Annual fee payment per person, Annual depreciation - OÉCS1 (HUF/person/yr), Amount of personal income tax base (1000 HUF), Number of residents, Number of homes connected to the drinking water pipeline network, total – 2018

Coefficients[a]

Model	Unstandardized Coefficients: B	Unstandardized Coefficients: Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	Collinearity Statistics: VIF
(Constant)	-113 456.866	61 699.178		-1.839	0.066		
Pipe length per capita (water-sewage) (rm/per person)	2 995.876	548.131	0.059	5.466	0.000	0.391	2.556
Number of homes connected to the drinking water pipeline network, total - 2018	53.420	40.637	0.255	1.315	0.189	0.001	810.491
Number of homes connected to the sewerage network (pc) - 2018	-32.369	28.973	-0.150	-1.117	0.264	0.003	386.602
Amount of personal income tax base (1000 HUF)	0.002	0.003	0.037	0.759	0.448	0.020	50.419
Residential water and sewer charges together (HUF/m^3) - 2019	50.239	49.431	0.010	1.016	0.310	0.467	2.143
Number of residents	-14.006	10.926	-0.145	-1.282	0.200	0.004	276.429

Amount of (domestic) wastewater discharged into the public wastewater collection network per capita (m^3) - 2018	1 678.935	1 228.874	0.021	1.366	0.172	0.194	5.152
Annual fee payment per person	-0.862	1.070	-0.015	-0.806	0.421	0.133	7.514
average quality indicator = ové/opé	1 496.837	746.409	0.020	2.005	0.045	0.466	2.147
Annual depreciation - OÉCS1 (HUF/person/yr)	54.202	1.215	1.107	44.626	0.000	0.075	13.273
Annual depreciation - OÉCS2 (HUF/person/yr)	-16.357	2.136	-0.188	-7.657	0.000	0.077	12.982
a. Dependent Variable: Replacement costs per capita during the examined life cycle - OPK/per capita (HUF/per person)							

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