SUBMISSION TO IRISH WATER

PUBLIC CONSULTATION ON THE NATIONAL WATER RESOURCES PLAN (NWRP)

February 2021

Introduction to An Fóram Uisce

An Fóram Uisce |The Water Forum was established in June 2018 in accordance with the provisions of Part 5 of the Water Services Act 2017 and is the only statutory body representative of all stakeholders with an interest in the quality of Ireland's water bodies. An Fóram Uisce consists of 26 members including representatives from a wide range of organisations with direct connections to issues relating to water quality and also public water consumers. Approximately 50 different organisations were involved in the nomination of members. Further information can be found at www.thewaterforum.ie.

Contents

Executive Summary of Submission

1. An Fóram Uisce (AFU) welcomes the opportunity to respond to the public consultation on the NWRP. The wide scope of work undertaken by Irish Water (IW) to develop the NWRP draft and the public consultation process is recognised.
2. This submission responds to each of the six questions posed in the public consultation document. The responses provided highlight key components of concern and provide suggestions for improvement to specific aspects of the proposed NWRMP framework. These suggestions aim to simplify, facilitate and assist IW to achieve its planning goals ensuring efficiency and effectiveness. This submission is presented in sections, with each section responding to each specific consultation question. A non-technical, summarising text-box is provided at the beginning of each section, followed by the detailed response to the question.
3. In developing the technical aspects of this submission, all forms of water scarcity are incorporated, using all relevant methods to address them, and including components beyond the traditional water management practices. Suggestions for further consideration and issues that need to be further highlighted refer to the main known problems identified by Irish Water:
    a. Leakage (which must be seen as an opportunity to improve the water systems overall, i.e. monitor & control)
    b. water quality improvements,
    c. enhance Irish Water with project and financial management resources,
    d. facilitate the management approach by reducing the number of Water Resource Zones
    e. plan for additional demand (related to Covid-19), and
    f. strengthen methodologies to include more solid and justified bases.
4. Issues related to poor data and uncertainties, certain methods which do not include controls, vague terminology, and simplistic/misleading definitions are also highlighted. Alternative approaches and ways to address the above are recommended and explained, including outlining necessary databases, adjusting the methods to revised needs, and using actual and literature-supported definitions of resilience-sustainability-flexibility. In addition, examples of alternative methods and their application by Irish Water are presented with advantages of using these methodologies including low data-requirements, the flexibility of the proposed methods' usage by IW, and allowing outcomes to be used to quantify the performance of future policies.
5. Specific aspects that cannot be covered by the consultation questions are also included in this submission (e.g. the case-specific features and challenges of the Greater Dublin Area, and the short-time frame for the public consultation process).

This document represents an agreed submission of An Fóram Uisce as a whole, and further engagement in relation to the content of this submission is warmly welcomed.

1. Introduction

An Fóram Uisce (AFU) welcomes Irish Water's efforts and communication of the NWRP (draft plan) for consultation. This submission from AFU uses an orderly approach, answering the specific questions within the public consultation document, and providing guidance with the aim of improving current practices. The submission addresses all forms of water scarcity and uses the principles of Sustainable Integrated Water Resource Management (SIWRM) to identify methodologies that address all forms of water scarcity (demand), efficient use of water resources (supply) and effective cooperation with all stakeholders.

An Fóram Uisce (AFU) welcomes the opportunity to respond to the public consultation on the National Water Resources Plan (NWRP) and recognizes the extensive and detailed effort to produce the public consultation document. The conceptual framework presented in the NWRP is based on solid theoretical approaches, however, AFU propose modifications to the methodology and conceptualisation, which is discussed in detail in the following sections. The approach and the background of the context of this submission is based on the principles of the modern and Sustainable Integrated Water Resources Management (SIWRM):

- Address every form of water scarcity[1]: a) Natural water scarcity, where the available amount of water is not enough for the coverage of all our needs, b) Economic water scarcity, where there is lack of the necessary investments for the coverage of water needs (limited financial, infrastructural, human, or legislative abilities to exploit with the optimum way the available water resources), c) Qualitative water scarcity, where water is not suitable for use, because of poor chemical condition, and further investments and infrastructure are required for the improvement of its quality.

- Use all the methods and activities required for the rational utilisation of water resources in order to fully meet the water needs; it includes[2]: a) Scientific methods and techniques (hydrological analysis, observation of the water resources, and the knowledge of the water demand timely and spatially), b) Operational interventions and administrative measures aiming to the maximum benefit from the use of water systems, according to criteria, priorities and goals, already set (socio-economic analysis), c) All technical works and legislation required, to achieve the above.

- To achieve the maximum efficiency of water resources use, and economic and social prosperity, SIWRM requires cooperation from the different actors involved, ensuring trust, and stakeholder involvement.

The following sections address the specific questions provided in the NWRP public consultation document.

[1] Kummu, M., Guillaume, J., de Moel, H. et al. (2016). The world's road to water scarcity: shortage and stress in the 20th century and pathways towards sustainability. Sci Rep 6, 38495 https://doi.org/10.1038/srep38495
[2] Loucks, D.P. van Beek, E. (2017). Water Quality Modeling and Prediction. In Water Resource Systems Planning and Management; Springer International Publishing: Cham; pp. 417–467 ISBN 978-3-319-44234-1.

2. NWRP Public Consultation Questions

2.1 Do you have any suggestions that you would like Irish Water to consider as part of the draft Framework Plan?

AFU provides suggestions for further consideration by Irish Water, and highlights key perspectives on the following issues:

- *Leakage (as an opportunity to control and improve the systems. Greater operational control is needed through metering and modelling; more technical innovations should be applied and consumer engagement for urgent action to reduce leakage)*
- *Water quality improvements, addressing wastewater treatment to protect source waters,*
- *Enhance IW with project and financial management resources and boost project management expertise,*
- *Facilitate the management approach by reducing the number of Water Resource Zones,*
- *Plan for additional demand (related to Covid-19),*

IW should aim to 'own' the functions and operations of the water supply systems in order to develop feasible solutions and seek continuous improvements in levels of service.

The suggestions for future consideration arise from the main existing issues that are being observed, and are related to IW's jurisdiction. These are associated with the key issues that have been identified by Irish Water:

- High **leakage** percentages. An Fóram Uisce recognises that progress to reduce leakage has been observed, but considers that greater and more urgent progress is necessary. Monitoring and use of technology is recommended in the following sections in further detail. Leakage, however, is not the only issue that requires attention.

- In relation to urban wastewater the EPA has, in its most recent Report[3], identified 113 priority areas where **improvements are needed to prevent water pollution**, eliminate discharges of **raw sewage**, meet EU treatment standards and **protect bathing waters and freshwater** pearl mussels. The EPA has called on IW to address the **delays** in providing **wastewater infrastructure** in order to deliver the water quality improvements needed to meet our Water Framework Directive and wastewater treatment objectives.

- The Scottish Water International's (SWI) Report[4,5] highlights the necessity of **investment, financial project management and delivery** improvements.

- The large number of Water Resource Zones (539).

- Changes in water demand. Covid-19 brought significant changes in water demand, distribution, network pressure and water treatment, and such changes due to COVID should be incorporated into the NWRP.

Considering the above, the suggestions for future consideration are presented below.

2.1.1 Leakage

The existing efforts on **leakage reduction** and their continuation are warmly supported by AFU, but greater urgency and ambition is required. To increase efficiency and effectiveness, the matter of leakage can be approached from the perspective of monitoring and controlling the water distribution system (WDS), while keeping in mind that the system interacts continuously with humans (a perspective absent

[3] https://www.epa.ie/pubs/reports/water/wastewater/urbanwastewatertreatmentin2019.html

[4]https://www.cru.ie/document_group/irish-water-revenue-control-3-2020-2024/cru20085b-scottish-water-international-report-iw-investment-and-delivery-review/

[5]https://www.cru.ie/wp-content/uploads/2020/08/CRU20085c-Addendum-to-Scottish-Water-International-Report-IW-Investment-and-Delivery-review-.pdf

from the draft plan). Thus, AFU propose that Irish Water consider approaching the system based on the following three pillars, going beyond the traditional fixes of reported leaks:

1) improve the operational control of the systems overall through monitoring, metering, modelling, and controlling the system. This can be a significant and swift improvement of the existing practice. Briefly, for the subdivision of the WDS into sufficiently small district metered areas (DMAs), there are numerous algorithms (e.g. Fast Greedy, Random Walk, and Metis) that can be easily used to establish them efficiently. Multiple algorithms[6] also exist for the optimal location[7] of installation of control valves and their real time control (RTC)[8], to meet the demand variations in time[9].

2) improve the systems overall, regarding leakage management. Taking the example of UK, several of the methods described in 1) above tactics are being applied into practice, and these, and more such methods, can be implemented by IW (as per p.145/178 of the Draft Plan). Some methods do not require large financial investment (e.g. satellite technology and underground listening equipment to detect leaks), and other solutions are available, such as drones to identify vegetation around leaks, rescheduling non-urgent works, mobile and fixed acoustic loggers to pinpoint leaks by measuring noise of water escaping, dogs trained to sniff out chlorine, WDS's pressure management, customer metering, etc[10]. If the WDS is being monitored, leakage can be estimated through night flow (minimised errors), as night consumption is minimal and potential leaks easier to determine[11]. Academic collaborations can result in the development of useful, cost-effective tools, for example, models for spatio-temporal simulation of leakage, using EPANET or similar software, mapping WDSs[12], and even leakage localization methodologies based on head pressure and flow measurements (which can reduce losses up to 70%).[13]

3) Include the social perspective. Humans play a crucial role in the monitoring and control of urban water distribution systems: i) as consumers they impose a significant (uncontrolled) disturbance to the system, ii) they may report if there is an abnormal operation of the system, and iii) they are also the controllers and policy makers, taking decisions, which affect the system as a whole. A first step can be the more systematic provision of educational and informational material (on all the issues mentioned in p.145/178 of the draft plan). For example, in the UK, OFWAT's website provides three such categories: on water saving tips for customers (self-habits for individuals)[14], promoting the efficient water use through available information and training[15], and material on droughts and the strategies used to tackle it[16]. Finally, a suggestion for IW to consider, is the inclusion of socially related criteria to the evaluation of its options in the MultiCriteria Analysis (MCA), as discussed further in Section 2.3.

Overall, leakage reduction can be seen as an opportunity to develop a broader plan for mapping, monitoring, controlling and metering the factors related to supply and demand estimation, providing

---

[6]Creaco, E.; Pezzinga, G. Comparison of Algorithms for the Optimal Location of Control Valves for Leakage Reduction in WDNs. Water 2018, 10, 466.

[7]Covelli, C.; Cozzolino, L.; Cimorrelli, L.; Della Morte, R.; Pianese, D. Optimal Location and Setting of PRVs in WDS for Leakage Minimization. Water Resour. Manag. 2016, 30, 1803–1817.

[8]Pezzinga, G.; Gueli, R. Discussion of "Optimal Location of Control Valves in Pipe Networks by Genetic Algorithm". J. Water Resour. Plan. Manag. 1999, 125, 65–67.

[9]Araujo, L.; Ramos, H.; Coelho, S. Pressure control for leakage minimisation in water distribution systems management. Water Resour. Manag. 2006, 20, 133–149

[10]Puust, R.; Kapelan, Z.; Savic, D.A.; Koppel, T. A review of methods for leakage management in pipe networks. Urban Water J. 2010, 7, 25–45.

[11]Cabrera, E.; Pellejero, I. Evaluation of leakage by means of night flow measurements and analytical discrimination. A comparative study. In Pumps, Electromechanical Devices and Systems Applied to Urban Water Management 1; Balkema Publisher: Lisse, The Netherlands, 2003; p. 327.

[12]Cobacho, R.; Arregui, F.; Soriano, J.; Cabrera, E. Including leakage in network models: An application to calibrate leak valves in EPANET. J. Water Supply Res. Technol. AQUA 2015, 64, 130–138.

[13]Sophocleous, S.; Savi´c, D.; Kapelan, Z. Leak Localization in a Real Water Distribution Network Based on Search-Space Reduction. J. Water Resour. Plan. Manag. 2019, 145.

[14] https://www.ofwat.gov.uk/households/conservingwater/watersavingtips/

[15] https://www.ofwat.gov.uk/households/conservingwater/help/

[16] https://www.ofwat.gov.uk/households/conservingwater/drought/

multiple benefits.

B) Regarding the matter of **raw sewage** discharge into receiving waters**,** we recognise the existing efforts to upgrade, replace and construct new WasteWater Treatment Plants (WWTPs). Although we acknowledge the distinction between sewage discharge and potable water issues concerned by the Draft Plan, given the magnitude of the problem, the environmental consequences, and the progress to date, AFU highlight the issue for IW's future plans.

C) Considering the findings and recommendations of the Scottish Water International report, and the outcomes of engagement between IW and AFU, with the development of a unit or a team of experienced **project-financial managers** further 's resourcing, based on solid budget and risks estimations. This suggestion can be seen as a small but significant investment to IW's capabilities.

D) As mentioned in the Draft Plan, the large number of **Water Resource Zones (WRZs)** is creating difficulties deliver efficient water services management. According to the Draft Plan (especially p. 35/178), it is proposed that IW will reduce the number of WRZs. This effort is strongly supported, and must be in line with the physically connected systems studied. The WRZs reduction's importance must be highlighted, as it will improve the management actions, and facilitate the country's Regional management approach. This action will also contribute to the creation of consistent databases, the better mapping of the WRZs, and the continuous monitoring, as also noted in the next sections.

E) National restrictions implemented as a result of the **Covid-19 pandemic** resulted in observed changes in water demand and pressures patterns to different nodes of WDS. For example, water demand increased by approximately 20% due to the increase in hygiene behaviours such as hand washing. The geographical location of water demand also transitioned from some industrial and working centres to residential areas for longer periods, so, at least for large urban centres, lessons learned during the Covid-19 pandemic can inform future planning. It is a good example of an exogenous factor (externality of the system) that not only can disturb "normal" operations, but can also exhibit characteristics of seasonality (e.g. it is a phenomenon/pressure that has been ongoing for one year and is likely to continue for many more months). Subsequently, the response of Ireland's water systems needs to be adjusted to cope with the changes in demand volume and geographic location over a prolonged period. AFU acknowledge that this issue may be perceived as a short-term threat, however, the increase in hygiene behaviour can be incorporated into longer-term panning[17], for example as an additional seasonal "headroom", or as another variable to the existing Supply Demand Balance (SDB) and its future estimation (forecast), or at least as an "uncertain factor" (Table 8.8 of the Draft Plan) for estimation under the "sensitivity analysis".

E) Some of the **methods** and practices presented in the draft plan are 'borrowed' from the UK (e.g. Final Water Resources Planning Guidelines 2016, Institute of Hydrology Report No. 108 for the water supply estimation). Although the draft plan mentions the differences between the UK and Irish situation, there is no mention of any proposals to develop alternatives tailored for Ireland. For example, in the draft plan (p.28) for each key difference with the UK, ideally there should be an alternative method or a solid plan to develop such. The benefits would be to reduce uncertainties, become methodologically independent and understanding the functionalities of the systems from firsthand, support the monitoring-recording-data gathering processes, understand deeper your systems in terms of physical and technical operation and needs, and motivate self-growth and a mindset of continuous improvement of all levels of services.

[17] https://www.waterbriefing.org/home/water-issues/item/17606-resilience-revisited-stress-testing-in-the-water-sector-after-the-pandemic

2.2 Do you have any suggestions that you would like Irish Water to consider as part of how we assess supply/demand balance, water quality, quantity and resilience?

AFU are concerned about some limitations in the methodologies presented in the draft plan. For example, supply-demand balance calculations are limited by poor data and uncertainties (e.g. using methods from similar UK catchments and streams). No validated methods for Ireland are used, rather "based on data from other water utilities".

Also, some vague terminology in the methods is provided in the draft plan. The definitions of resilience-sustainability-flexibility provided in the draft plan are very simplistic and misleading, given the important role they play for the planning process.

For the Supply-Demand Balance we recommend: As current data gaps and proposed methods could lead to mis-estimations it is important that IW increase data availability and adjust methods in due course to allow the building of solid bases that would enable more efficient water resources management.

AFU have provided commonly-accepted definitions of resilience-sustainability-flexibility, and examples for their easier application by IW are explained below. The advantages of taking the proposed approaches include the ability to facilitate the current low availability of data, the ability of IW to define the scale, the future hazards-threats to the supply-demand balance, and the water supply operation standards in a justified way, and to use the outcome to quantify the performance of future policies.

2.2.1 Supply-Demand Balance

Supply-demand balance is a standard tool with abundant literature and models available to support its implementation. IW follows the methods proposed by the UK Water Industry Research Ltd (UKWIR) WR27 Water Resources Planning Tools (2012), Institute of Hydrology Report No. 108 Low flow estimation in the United Kingdom Methodology, and UKWIR 2013 study 'Impact of Climate Change on Demand'.

Since adopting such concepts is preferred than a hydrological and water balance analysis, then they must be considered carefully, and not just as executable estimation tools. This is because of the uncertainties which exist because of the methodologies' inherent lack of in-depth analysis for the Irish case conditions. The Deployable Output, for example, is limited by hydrological yield uncertainties, in addition to its own great uncertainties. The Flow Duration Curves (FDC) are based on the transposition method from similar catchments-streams, while in Appendix-C, there is no information on how to estimate all these parameters (same with Wet and Dry critical periods) with a numerical example. The calibration and validation of models (at least in a couple of case studies) is crucial because it allows a level of acceptable error to be defined and proceeded with. Examining Appendix-C, it can be assumed that only the hydrological yield has been calibrated for some UK areas, but not for Ireland. Moreover, the assumptions made to perform the discussed methods are not discussed, so the processes' results seem to have been derived from a "black-box" estimation.

Both the Weather Event Planning scenarios and the peaking factors presented are also subject to uncertainties since they "*are based on data from other water utilities*" and the estimations are index-based (not process or data-based). A "sensitivity" analysis was included but seems more qualitative (e.g. high, moderate, low likelihood and impact), rather than quantitative. Sensitivity analyses are standard components of water resources planning studies, and usually, considering a "range" of values for the various parameters used in the projections would have allowed several possible evolutions of the system to be modelled. In contrast, the sensitivity analyses presented in this draft plan are based on hypotheses without characterizing the "level of confidence" attached to them. "Headroom" is used as a way to address these uncertainties "*in line with UK guidance*", but the estimation is vague and there is no adequately explained example. The estimations of demand and its components are neither presented in Appendix-L.

Regarding water quality, sampling should be more frequent. Improving water quality monitoring would assist Irish Water in addressing to the aforementioned EPA's recommendations regarding the upgrades on wastewater disposal practices.

It is understandable that implementing the methods presented in the draft plan is a way to proceed given the lack of available data in Ireland, and the efforts to address this are acknowledged. However, this compromise must be accompanied by:

1. The agreement that there are serious gaps in the current data levels and potential misestimations due to the adjustments of other methods (affecting all WRZs as they include all possible surface and groundwater resources). Thus, it is essential to improve the methodology in due course
2. Improving data collection and monitoring to fill data gaps.
3. Assessing current uncertainties and assumptions to guide the analysis to the parameters that need refining.
4. A recalculation of the forecasting to 2044 following improvements to data availability and hydrological simulations.

In order to improve data availability, monitoring and metering, in the highest scale-resolution possible, are critical, allowing for improvements in the methodology (e.g. hydrological yield, forecasts, peak factors, headroom), and increase confidence in the soundness and reliability of the water demand estimation, supply capacity and water balance (in at least quarterly or monthly basis). Forecasts are suggested to be based on past events using the appropriate practices (i.e. extreme, frequency analysis). With the above suggestions, IW will know each stress on time to adjust its strategies (*a priori* planning, not *posteriori* to the problems).

2.2.2 Resilience

With respect to **Resilience**, the concept of "*Does the option address the supply-demand problem?*" (p.148 of the Draft Plan) is not relevant to the concept of resilience. In fact, it is only an opinion of a respondent to the assessment question "if the examined management option avoids a deficit water balance" (p.148/178 of the draft plan). Avoiding deficits is a much more primitive process (not even risk-based) than considering a system resilient. Resilience should be considered in the context of System Theory, i.e. referring to specific systems (e.g. a sub-catchment, a reservoir, a water distribution network, a WWTP, etc.). A broader, measurable, sustainability-connected definition of resilience, well-supported by the relevant literature, could be: "*The ability of a WDS to resist, absorb, accommodate, and recover from the efforts of a hazard in a timely and efficient manner*"[18,19,20]. This is a combinative short but comprehensive definition, so it is practically deconstructed below[21]:

- Resist to and Absorb a hazard = The degree of disturbance (magnitude of the external pressure - hazard) up to which the system can continue to operate (without changing its functionality) before changing its initial state.
- Accommodate to the hazard = To continue operating without failures (non-functionality), when the hazard goes beyond the absorption limit, the system redefines its functional conditions by changing the variables and processes that control its behavior. This stage can be achieved either by the operator's intervention, or a systems self-organization to retain essential structures, or their combination.

---

[18] United Nations International Strategy for Disaster Risk Reduction (UNISDR). 2012. *How to make cities more resilient: a handbook for local government leaders.* UNISDR, Geneva, Switzerland. [online] URL: http://www.unisdr.org/we/inform/ publications/26462
[19] Adger, W. N., T. P. Hughes, C. Folke, S. R. Carpenter, and J. Rockström. 2005. Social-ecological resilience to coastal disasters. *Science* 309:1036-1039. http://dx.doi.org/10.1126/science.1112122
[20] Folke, C., 2006. Resilience: the emergence of a perspective for social-ecological systems analyses. Global Environmental Change 16 (3), 253–267.
[21] Hashimoto, T., Stedinger, J. R., and Loucks, D. P. 1982. "Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation." Water Resour. Res., 18(1), 14–20.

- Recover from the hazard = The return time to a steady (or the initial) state following a perturbation. Many processes can take place at this stage, including the progressions (learn & adapt) and feedbacks and the degree to which the system and its operators can (re)build the capacity.
- Do the above Timely and efficiently = The transition between these phases (transformability) requires a flexibility in management and secure technical characteristics, so that a WDS's reorganization will continue to cover the water user's needs satisfactorily.

The above parts can be measured from the extent to which external conditions change (e.g. increment in the demand, pollution, spatial variation of demand, etc.), in relation to the WDS's continuation of providing the same quality of services, over time (or users' evaluation from the social perspective). For example, functions of time (curves) or indicators (performance indices) related to magnitude and time (or sometimes frequency of events' occurrence) can be used to assess the resilience. It is important that resilience is included in the process, in addition to the risk-based evaluation of system performance (which is not adequately addressed in this plan). This is because, compared to the classic 'risk approach', the concept of resilience addresses the 'hazard' differently: we say resilience *TO* something (external cause, that needs to be defined), while risk is risk *OF* something happening (internal cause, that is known).

AFU acknowledge that these concepts and their mathematics can be complicated and can be limited by data availability. Subsequently, two alternative methods are proposed, using simplifying assumptions and not being limited by low data availability.

Resilience Proposal 1:

In a simplified way, Resilience can be considered as a measure of how quickly the system recovers from the failure state[22]:

$$\text{resilience} = \frac{\Pr\{x_t \in F \text{ and } x_{t+1} \in S\}}{\Pr\{x_t \in F\}} \qquad (1)$$

Where t expresses the time interval, the satisfactory state of a hazard variable x is S, and its failure state is F. Thus, it is possible to choose: a) the system (as it can be defined in accordance with the hazards considered); b) define the variable x that will represent the hazards; and c) set their thresholds to describe the F/ S states. Data availability are not an issue with this approach (i.e. custom definition of the above three factors). The only thing to be observed is the conditional probability (Pr) of an S state following an F state.

For example, in a daily time step, resilience equal to 1 indicates that a system recovers from the failure immediately and Resilience equal to 0.5 indicates that a system recovers after the failure in 2 days on average. For the example of a reservoir (as system) and temperature (as hazard x), one can use the historic (observed) upper and/or lower temperatures caused problems, as thresholds to determine the system failure F for the calculation of resilience. If a daily temperature, for instance, is within these two values, the system is in a satisfactory state S, and if not then it is under failure F. Alternatively, the demand or other factors can be set as exogenous hazards, or the reservoir's level can be a threshold, or past data of IW on known failures. Similarly, this formula can work with other systems, as mentioned above. This approach, known as Hashimoto's resilience measure, has been widely used and cited, because it is simple and can be applied with custom modifications, too[23].

Resilience Proposal 2:

---

[22] Hashimoto, T. Stedinger, J.R. Loucks, D.P. (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. Water Resour. Res. 18, 14–20.

[23] Eum H., Simonovic S. (2012). Assessment on variability of extreme climate events for the Upper Thames River basin in Canada. Hydrol. Process. 485-499 (2012).

A slightly more complicated and more accurate method is to consider resilience as the integral of the physical, economic, and organizational units (i). These three impacts units of resilience (r_i) are considered in this example, but the general measure is not limited to them. Measure of system performance $P_i(t,s)$ for each impact (i) is expressed in the impact units[24]:

- Measures of performance for physical impacts may include length [*km*] of road being inundated by a flood, or the reduction in water supply [m^3/s] due to pipe break, or the area of the city [km^2] that is under the water during a flood event or without water supply in a disruption, or the level of the reservoir [*m*] that provides a minimum level of supply, and so on.
- The economic impacts can be measured using aggregates or more sophisticated expressions of production, supply and consumption chains. For example, production functions tailored to your O&M costs using the respective water and/or damage elasticities, etc.
- The organizational impacts can be measured using number of disaster management services available to the population, or the time [*hr*] required under the current regulations to provide assistance or process a damage claim, or similar.

This approach is based on the notion that an impact, $P_i(t,s)$, which varies with time and location in space, defines a particular resilience component of a system under consideration (Fig.1a). The area between the initial performance line $P_{0i}(t,s)$ and performance line $P_i(t,s)$ represents the loss of system performance, and the area under the performance line $P_i(t,s)$ represents the system resilience $r_i(t,s)$.

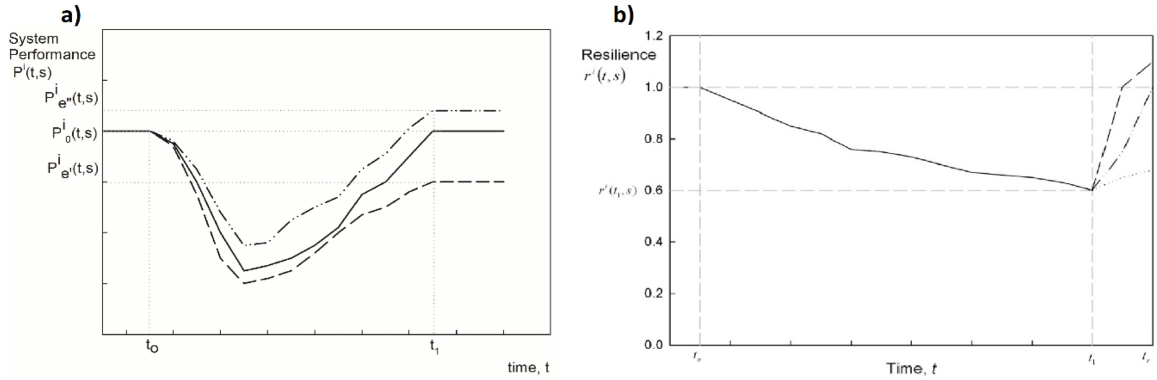

Figure 1. a) Conceptual definition of the resilience measure, b) System resilience. Adapted from Simonovic and Peck (2013)[22].

For the sake of demonstration, let us denote with t_0 the beginning of the disturbance, t_1 the end, and t_r the end of the recovery period (as in Fig1.a). Then, the aforementioned loss of resilience for impacts (i) represents the area under the performance graph between the beginning of the system disruption event at time (t_0) and the end of the disruption recovery process at time t_r. Changes in system performance can be represented mathematically as described in the previous paragraph:

Area of the performance loss part of Fig.1a: $\rho_i(t,s) = \int_{t_0}^{t}[P_{i0} - P_i(\tau,s)]d\tau$, with $t \in (t_0, t_r)$ (2)

Resilience as in Fig.1b: $r_i(t,s) = 1 - \left(\frac{\rho_i(t,s)}{P_{i0} \times (t-t_0)}\right)$ (3)

When performance does not deteriorate due to disruption $P_{i0}(t,s) = P_i(t,s)$, the loss of resilience is 0 (i.e. the system is in the same state as at the beginning of disruption). When all of system performance is lost, $P_i(t,s) = 0$, the loss of resilience is at the maximum value. The system resilience, $r_i(t,s)$ can be calculated by Eq.(3) (Fig.1b). In other words, resilience can be found as a function of the system's performance deterioration ratio to its initial condition.

This approach gives IW the ability to choose: a) the systems to be examined, b) the hazards, and c) the

[24] Simonovic, S.P., Peck, A., Dynamic resilience to climate change caused natural disasters in coastal megacities quantification framework. *British Journal of Environment & Climate Change,* **3**(3), pp. 378–401, 2013.

systems' initial performance and performance under each disturbance (which can be easily considered from observed stresses by IW). Moreover, IW has the freedom to adopt a more general 'disruption' to its systems (of course, multiple hazards can be considered, too, and then the r_i 's can be summed). For further details, indicative data requirements, a guide to this approach, and a recent review on similar applications, see also Simonovic (2016; 2020)[25,26].

Similarly, the rest of the 'criteria' of Table 8.4 in the draft plan can be revised.

2.2.3 Sustainability

<u>**Sustainability**</u>, cannot be restricted to being defined as to "avoid the known environmental impacts" as stated in the draft plan (p.148/178 of the draft plan), because that should be ensured in some way by every option. Instead, it should reflect the reserves of adequate water volume of good quality available for the future[27]. This can only be achieved following hydrological and water quality modelling, considering future demand and ideally establishing water use and pollution limits. Then, each option can be evaluated based on the degree it achieves (or approaches) these goals. Sustainability can be measured as the water availability of each water body after n years (or in a year-target) of the analysis[28]. The approaches to measure it using indices are similar to the suggestions given earlier for resilience, i.e. based on a systemic theory and often using environmental, socio-economic, and institutional indicators[29]. Other simple tools that can be used have been proposed by: Sakellari et al. (2005)[30], who developed a user-friendly Decision Support Tool for evaluating sustainability options for urban water management; and Jensen and Khali (2020)[31] who provided an indicator-based prioritization for sustainability of urban water system options. Finally, sustainability must not be considered only in an environmental context, but also economically, and, to quote Scottish Water International: "*it's necessary to have some reserves for the future*"[32]. Thus, the economic impacts of each policy must be considered (ideally through a project management team, or even as the second impact factor of the Resilience Proposal 2 above).

2.2.4 Flexibility

<u>**Flexibility**</u> is not just a "risk and uncertainty mitigation to avoid failure of the Option" (p.148/178 of the draft plan), rather, it is the ability to change options if the results are not satisfactory. For long-term planning, flexibility (the ability to implement a first-stage solution while keeping a view of the long-term system development) is close to robustness (the ability of a solution to satisfy as many future scenarios as possible)[33]. <u>The general suggestion for the whole set of these 'criteria' is to consider them based on systems theory, using measurable indicators, allowing for a uniform approach-framework</u> (as the one

---

[25] Simonovic S. (2016). From risk management to quantitative disaster resilience – a paradigm shift. Int. J. of Safety and Security Eng., Vol. 6, No. 2 (2016) 85–95.

[26] Simonovic, S. (2020). Application of the Systems Approach to the Management of Complex Water Systems. Water, 12, 2923.

[27] Marques, R. C., Cruz, N. F., & Pires, J. (2015). Measuring the sustainability of urban water services. Environmental Science & Policy, 54, 142-151.

[28] Rathnayaka, K., Malano, H., & Arora, M. (2016). Assessment of Sustainability of Urban Water Supply and Demand Management Options: A Comprehensive Approach. Water, 8(12), 595.

[29] Maiolo M., Pantusa D. (2019) Sustainable Water Management Index, SWaM_Index, Cogent Engineering, 6:1, 1603817.

[30] Sakellari I, Makropoulos C, Butler D, Memon FA (2005). Modelling sustainable urban water management options. Proceedings of the Institution of Civil Engineers. Engineering Sustainability 158(ES3): 143–153.

[31] Jensen O, Khalis A (2020) Urban water systems: Development of micro-level indicators to support integrated policy. PLoS ONE 15(2): e0228295.

[32] https://www.cru.ie/document_group/irish-water-revenue-control-3-2020-2024/cru20085b-scottish-water-international-report-iw-investment-and-delivery-review/ (p.18-19)

[33] Marques, J., Cunha, M. and Savić, DA, 2015. Multi-objective optimization of water distribution systems based on a real options approach. Environmental Modeling & Software , 63 , pp.1-13.

*And again, this scoring is a simplistic alternative until the conditions are ready to enable their modelling. Because if decision-making process that leaves these performances up to the decisionmaker's judgment is established, it will cultivate a mindset that will make difficult any future effort of quantifying and knowing the WRZs and the proposed solutions.

described herein using the resilience example, as highlighted by the consultation question – of section 2).

2.3 The draft Framework Plan sets out Irish Water's methodology to find high level solutions to address short, medium and long-term issues. Do you have any comments on our methodology?

By using the recommendations made in Section 2.2 above, the solutions' approach can be simplified and become more objective, and lead thus to a fairer ranking of alternative options. The broad set of alternative options described in the Draft Plan to address short, medium and long-term issues is welcomed, although it is practically more restricted to the short-term component. This section provides an example of a different MultiCriteria Analysis approach to achieve the above by evaluating the alternative options accordingly. MultiCriteria Analysis, where the criteria can be indicators that are (ideally) monitored, measured or modelled so that the result-performance is specific and known (in a defined system such as a water supply zone or sub-catchment). This results in the development of simpler and transparent processes, and more objective solutions for short, medium and long-term issues.

The draft plan highlights that measurable goals/outcomes are not set for some variables of the analysis in a year-target. This makes the draft plan appear more short-term oriented, and this indicates the importance for IW to incorporate the project planning and efficiency recommendations made in the Scottish Water International report.

The stages of the option selection presented in the draft plan (e.g. "fine screening" and "feasible options") appear complicated and more complex than a single MultiCriteria Analysis (MCA) application, because the feasibility is tested after the MCA model, and the selection of the preferred options uses criteria that could have already been considered. This introduces a degree of subjectivity under the perspective of the parameters used to 'filter' the options (e.g. least cost, quickest delivery, etc. as in Table 8.7). In fact, as described in the draft plan, the MCA results are being processed under "*Option costing encompassing Direct and Indirect Costs including Environmental and Social Costing*", following an analysis of the remaining options based on risk and then the preferred ones are selected. Following the limitations mentioned in Section 2.2, the methods used in this part, (e.g. the way to score the criteria) are not as clear as would be expected, given the qualitative approach used. This process could be clarified and potentially simplified. Alternatively, a straightforward example is provided below as a potential suggestion to facilitate this process:

Following the comments and the systemic perspective to approach resilience, sustainability and flexibility we described in Section 2.2, it is recommended that the MCA criteria (Table 8.6 in the draft plan) must not be seen as questions to be answered. On the basis previously described, these criteria can be indicators that (ideally) can be monitored, measured, or modelled so the result-performance should be specific (a defined system) and known. Then, a single MCA can be used for the overall ranking of the options, instead of relying on "fine-screening".

2.3.1 Proposed MCA Analysis

An MCA analysis is proposed using formula 4, below. A simple ad-hoc calculation based on Table 8.3 (e.g. added supply capacity, demand reduction, etc.) can be used that each option **i** can offer. By using these estimations, a score can be assigned (e.g. 1-10) to each one of the criteria and sub-criteria of Tables 8.4 and 8.6 of the draft plan. For the purpose of this example, below (and as mentioned above) these will not be referred as criteria, but as indicators (because they are supposed to be known values **Vi**)*. The components of social acceptance and stakeholder cooperation can be added for each measure. For scoring the indicators, a meeting or a consultation with representatives of the WRZ can take place. After weighting the alternatives, the "approaches" presented in Table 8.7 can be used as criteria. More criteria tailored to the WRZ's or regional needs can also be included, and these criteria ranked in order of importance. The result of the criteria ranking informs the decision-making process. Using the 'approaches' as criteria allows the options to be weighted, whereas this is not possible if they are used as 'approches' because often one approach is chosen and followed. Consequently, the "criteria" become measurable performances, and the "approaches" become the criteria, allowing a more fair comparison of the options, avoiding extra analyses.

After the performance values Vi of the options are known (modelled or scored), and the criteria set is complete, we can give a score **Si** to the criteria (as we call them from now on) of Table 8.7 of the draft plan. The scoring based on the Appendix-N-Fine-Screening guide (Table 1.3.) is applicable (avoiding negative scoring scale). Finally, options **i** can be ranked, applying a simple additive utility function (**Ui**), of their sub-criteria performances:

$$U_i = \sum_i (V_i S_i) \quad (4)$$

The simple MCA example described above aims to simplify and make the overall process more objective, and avoid using it as a step for further processing the preferred "approaches", while aligning with the relevant literature[34,35]: The studies of von Neumann and Morgenstern, and Savage in 1940–1950, modelled a value-weight system, similar to a decision maker's logic[36]. This approach became the most indicative example of using utility functions which allow for risk consideration while indicating the preferences[37]. Currently, the additive utility function of Eq.(4) is its most widely used form, where the alternative with the highest utility Ui is considered to be the most appropriate[38].

Finally, this method uses sub-criteria, so it can be consistent with the design of IW, which uses (independent) sub-criteria (Table 8.6 of the draft plan). The independence of criteria (using simple correlation tests) can reduce further their number by removing those criteria which are significantly correlated. Therefore, the results are more objective (not double-estimations) and the calculations become simpler. For a more detailed, step-by-step guide to the above approach, see Munier (2011)[39].

The proposed method of ranking the alternative options does not exclude a bottom-up approach on the options' development. On the contrary, it is encouraging it as the only realistic way to start with, given the current data uncertainties (e.g. location of pipes, consumption, pressures, capacities, operation statuses, etc.). The present document sets as a basis the monitoring of all these systems' features and data, and hence regard it as a system, when it comes to the decision-making process.

2.4 Do you have any comments on the Strategic Environmental Assessment (SEA) Environmental Report and associated Natura Impact Statement (NIS) which accompanies the draft Framework Plan?

The accompanying documents are in line with the Draft Plan. AFU are cautions about the level of ambition of the SEA and NIS considering the lack of data, monitoring and metering mentioned earlier. Significant resources will be required to achieve the goals for the resilient supply and levels of service objectives of the NWRP.

---

[34]Neumann, J.V., Morgenstern, O. Theory of Games and Economic Behavior; Princeton University Press: Princeton, NJ, USA, 1953; ISBN 9780691130613.

[35] Churchman, C.W.; Ackoff, R.L.; Arnoff, E.L. Introduction to Operations Research;Wiley: New York, NY, USA, 1957.

[36] Keeney, R.L.; Raiffa, H. Decisions with Multiple Objectives; Wiley: New York, NY, USA, 1976; 569p, ISBN 0-521-44185-4.

[37] Fishburn, P.C. Utility theory. Manag. Sci. 1968, 14, 335–378. / Fishburn, P.C. A Survey of Multiattribute/11multiple Criteria Evaluation Theories; Multiple Criteria Problem, Solving, Zionts, S., Eds.; Springer: Berlin, Germany, 1978; pp. 181–224. / Fishburn, P.C. Utility Theory for Decision Making; John Wiley and Sons: New York, NY, USA, 1970; Volume 6.

[38] Sintonen, H. An approach to measuring and valuing health states. Soc. Sci. Med. 1981, 15, 55–65.

[39] Munier, N. (2011). A Strategy for Using Multicriteria Analysis in Decision-Making. A Guide for Simple and Complex Environmental Projects; Springer: Dordrecht, The Netherlands; Heidelberg, Germany; London, UK; New York, NY, USA, 2011; ISBN 978-94-007-1511-0, e-ISBN 978-94-007-1512-7.

The accompanying documents are in line with the NWRP. The main considerations have been highlighted in the previous sections: issues like monitoring, leakage, project and financial management, addressing potential future delays in implementation, as well as emerging challenges such as Covid-19, and the consideration of social factors in the planning process.

The methods provided regarding the supply and demand balance, the usage of the concepts of resilience, sustainability, and flexibility, and also the decision-making process design have been analysed and presented above in the preceeding sections.

The SEA and NIS are detailed,covering most of the issues already described in the draft plan. However, under the current status in terms of data, monitoring, metering, and developing methods, the overall goals set seem quite ambitious and, consequently, AFU is cautious as to whether they can be achieved. It is therefore critical that the appropriate resourcing models areapplied to ensure that the goals and objectives of the NRWP can be achieved.

2.5 The project roadmap has been updated. Do you have any comments or feedback on this?

The timeframes for revising the Draft Plan and releasing the Regional Water Resources Plan seem tight to make revisions based on submissions received through the public consultation process.

2.6 How would you like Irish Water to communicate with you as the NWRP progresses?

AFU warmly welcomes the engagement with IW in advance of, during and post the NWRP public consultation period. Any engagement regarding the content of this submission and other aspect relating to the NWRP can be addressed to:

Donal Purcell, Senior Executive Officer, An Fóram Uisce,

Civic Offices, Limerick Road, Nenagh, County Tipperary

Email: donal@nationalwaterforum.ie

3. Other specific comments

Aspects of the draft plan that cannot be covered within the previous sections are mentioned in this section. Considering the economic importance of the Greater Dublin Area and its vulnerable position in relation to water supply, AFU recommends inclusion of the GDA water supply issue in the NWRP. AFU believe doing so is likely to result in more urgent action in addressing this particularly critical need. The short-time frame of the NWRP public consultation period is of concern to the AFU and we would like to draw attention to our briefing document on public participation in water resource management.

3.1 Greater Dublin Area

While AFU acknowledges that the NWRP public consultation process is not seeking comments on any particular projects and that the case study presented in the public consultation document is for demonstration purposes, it is considered that a more detailed report on the public water supply issue in the Greater Dublin Area (GDA) within the NWRP is required. The case study used as an example in the draft plan is not a representative example of GDA's issues. The threats that are already mentioned in the Draft Plan make GDA a specific case, set an urgent priority for it, thus it is important for raising awareness on this issue.

For the next 10 years, the main pressures are:

- increasing population (migration/urbanization)[40],
- increased consumption for increased hygiene, up to 20%[41],
- inadequate catchment sources (no natural lakes within 50 km of Dublin city, and no major aquifers exist within Dublin City Council's jurisdictional boundary),
- old and ageing infrastructure (treatment facilities and distribution network) – around 30% leakage in the city[42]
- inadequate incentives for conservation
- climate change (connection of drier summers with extreme rainfall events)
- pollution, increased needs for already overloaded WWTPs.

IW have currently (as of December 2020) 12 leakage reduction projects in progress for the whole of County Dublin, and none further planned that AFU are currently aware of. General aims are to address leakage, and deliver network upgrades (new water mains, sewage emergency storage tank, gravity inlet sewers, emergency overflow pipelines, etc.), and the eight planned projects refer to WWTPs and reservoir works. Even with some further progress in tackling leakage, it is likely that it will not be enough to balance the increasing water demand in the coming years given the current rates of population growth and water consumption for increased hygiene practices and changes in geography of water consumption due to changing working behaviours and locations. And of course, increased future demand is not the only environmental pressure. These observations are in line with a previous report of AFU[43] which highlights the critical needs of GDA that must be addressed urgently. Again, we recognise that this document highlights specific methodologies and approaches AFU believe can enhance the NWRP, however it is imperative to address the above in the GDA without delay.

3.2 Public consultation process

The Public Consultation process for the NWRP framework is described by IW as a 10-week statutory process from Tuesday the 8th December 2020 to 16th February 2021, over a holiday period, and with a recently added a 2-week extension. The Plan once adopted, later this year, will be a 25-year plan, and will result in a very significant impact on the country's population and activities related to water and water services. The concept of Consultation implies Engagement, Dialogue and Transparency. The latter means the tracking of changes on the original Draft Plan, demonstrating participant influences.[44] While it is recognised that IW have adhered to the statutory timeframes for delivering public consultation, it should be noted that this is the absolute *minimum* period of consultation required. In 2020, AFU released a briefing document on public engagement in water resources management[45], the principles of which are applicable to public consultation process undertaken by Irish Water. AFU encourages IW to examine these principles and how their public engagement processes can address any limitations of engagement.

---

[40] https://www.macrotrends.net/cities/21542/dublin/population and https://data.cso.ie/

[41] https://www.thewaterforum.ie/app/uploads/2020/06/An-Foram-Uisce-PR-in-response-to-IW-imminent-Water-Conservation-Order-020620.pdf

[42] Dublin City Council. 2010*b. The plan: water supply project - Dublin region.* Dublin City Council, Dublin, Ireland https://www.water.ie/projects-plans/

[43] https://thewaterforum.ie/app/uploads/2020/03/REPORT-to-An-Fo%CC%81ram-on-the-WSP-by-Nelly-Maublanc-May-2019.pdf

[44] OECD (Background Document on Public Consultation). Available at: https://www.oecd.org/mena/governance/36785341.pdf

[45] https://thewaterforum.ie/app/uploads/2020/03/Water-Forum_Public-Participation_Bresnihan-and-Hesse_2019.pdf

4. Concluding Remarks

AFU recognizes the significant effort and body of work undertaken to produce the NWRP framework public consultation document. It is imperative that IW must continue its efforts on maintaining and upgrading water services infrastructure, however, it is also necessary to examine its systems in a more dynamic way, and to further understand the drivers of water demand and plan accordingly, balancing realistic short and long-term goals.

Water systems evolve in time due to their expansion to new areas, the addition of new structures and instrumentation, the decommissioning of old infrastructure, changes in the system topology, fluctuations in the population dynamics and demographics, etc. Monitoring and metering by using data of acceptable quality regarding the physical processes, and consumer data, will facilitate better modelling. This in turn, will improve understanding of the changing system dynamics, which will indicate the most appropriate set of options. Education and training are an important starting point for the above suggestions to be put efficiently into practice.

In order to improve data availability and to further understand the drivers of water demand, consideration should be given to re-establishing IW's domestic metering programme. AFU recognises that this is a sensitive national issue and that a programme of public engagement and awareness raising would be imperative prior to any such re-establishment.

Improving such data availability through increased metering would allow any upcoming measure to be applied in a volumetric basis. In parallel, consumers can be further informed of their water consumption (for example, AFU has previously suggested the provision of such information to consumers through a 'Statement of usage'[46]). AFU has also recommended the development of an App[47], so that customers can monitor their use without having to check the IW website. AFU (and CRU) have suggested to inform customers how to reduce their water usage; the importance and benefits of doing so also needs to be further highlighted in the draft plan.

Improving performance (whether on leakage, demand management or operations in general) takes time and depends on many conditions (human resources capabilities, leadership, financial resources and above all regulatory pressure/support).

***It is impossible to plan efficiently for uncertainties, if the 'certainty' of the current state is not well understood and controlled*.**

Thus, instead of putting unreasonable pressure on IW, it would be safer to start with the above suggestions, to build on solid bases, and secure the necessary resources in order for IW to increase its efficiency and capabilities.

[46] https://thewaterforum.ie/app/uploads/2021/01/Submission-to-the-CRU-on-IW-PAF-17-November-2020.pdf (p.4-5)

[47] https://thewaterforum.ie/app/uploads/2020/05/Submission-to-CRU-on-IW-Non-Domestic-Handbook-22nd-May-2020.pdf (p.4).