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To cite this article: Erik Barnes *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **588** 042009

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Reviewing the adaption of a wellbeing framework for asset management investment analysis on a three waters network

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Abstract.

Water infrastructure world-wide is facing a number of pressures including increasing demand due to population growth and urbanisation, increasing legislative requirements, climate change, and ageing infrastructure. Supporting growth and prosperity across the country require smarter investment decisions to deliver cost-effective and innovative solutions. The focus on investment planning is moving away from the simple economic or risk-based decision to community wellbeing.

The New Zealand Treasury has developed a wellbeing framework to guide policy and investment that focuses on improved community outcomes for the nation. The purpose of this framework is to track changes to the wellbeing outcomes over time and improve public policy making, with the ultimate goal of lifting living standards and improving intergenerational wellbeing. This framework, largely based on the OECD wellbeing framework, was adapted for New Zealand (NZ) and includes a stock model to simulate the inter-relationship between investment and wellbeing outcomes. This framework focuses more on providing guidelines around the domains of wellbeing from a macro policy level decision making level, however their linkages to localized infrastructure development are weak.

This paper describes a strategy to develop a holistic decision-making framework for three waters (drinking water, wastewater, & stormwater), which include; finding the impact of investment in three waters on community's wellbeing, conducting performance analysis, and the development of a mathematical model and trade-off model for such investment. The results have suggested that the existing wellbeing framework provides an excellent monitoring framework for water infrastructure, yet to establish inter-relationships between wellbeing factors on a meso-level, a different model needs to be considered.

Keywords: Wellbeing, Intergenerational wellbeing, Asset management, Sustainability, Investment Monitoring, Water Infrastructure, Decision Making Framework, Three-waters, Macro, Meso and Micro level

1. Introduction

1.1. The Context of Investment into Wellbeing

There is no doubt that the provision and upkeep of infrastructure services have significant benefits to communities. Traditionally, most investment in infrastructure has been analysed and planned



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according to economic principles. In some cases, for example investment in developing countries, consideration of socio-economics has taken place.

The turn of the century has seen a new evolution in investment thinking away from a purely economic viewpoint toward aiming investment directly to improve the long-term wellbeing of societies in a sustainable manner. A number of factors have contributed to this shift in investment analysis including:

- economic analyses by themselves, do not fully address the long-term needs and prosperity of communities. OECD 2001 [4] illustrates how economic growth is a part of community wellbeing, but it does not capture the full dimension of what makes a community prosper or ensure sustainability in the long-term;
- with increasing demands on infrastructure services such as population growth, demographic shifts, urbanisation, climate change and ageing infrastructure there is also a requirement for investment to target “what matters most” to the communities, something that is not always explained in economic terms; and,
- in the information age, there is a wealth of information available to the customers of particular infrastructure service, giving them the ability to question the logic behind investment decisions. This leaves the infrastructure owners or service providers with increased pressure to demonstrate how the outcome of their investment will impact the community using reporting matrices that they relate to such as health, employment, education and personal wealth.

1.2. Objectives of the Paper

This paper describes a strategy to develop a holistic decision-making framework for three waters. The objectives are to:

- introduce the NZ wellbeing framework and mathematical model that monitors the change in wellbeing at a national macro level;
- demonstrate the development of a wellbeing performance framework on a specific asset group (three waters) that could be adopted at a Meso-level (city council or municipality level); and,
- explore the interactions between investment streams and impact areas, particularly related to the water services and infrastructure.

2. The New Zealand Wellbeing Model

2.1. NZ Treasury Living Standards Framework

New Zealand has embraced the concept of embedding sustainable variables into policy decision making through the use of the wellbeing domains and capitals in the NZ Treasury Living Standards Framework (LSF). This framework has been utilised for the first time at a national level providing the basis for New Zealand’s recently launched Wellbeing Budget [11]. Rt Hon Jacinda Ardern, Prime Minister of New Zealand, has indicated in the Wellbeing Budget, “...while economic growth is important – and something we will continue to pursue – it alone does not guarantee improvements to our living standards. Nor does it measure the quality of economic activity or take into account who benefits and who is left out or left behind...Growth alone does not lead to a great country. So it’s time to focus on those things that do...we have broadened our definition of success for our country to one that incorporates not just the health of our finances, but also of our natural resources, people, and communities” [11]. The New Zealand Government defined wellbeing in the Wellbeing Budget as, “...when people are able to lead fulfilling lives with purpose, balance, and meaning to them” [11].

2.2. Introducing NZ Wellbeing and Connection to Sustainability Development Goals (SDG)

Wellbeing can be defined as the objective and subjective conditions that lead to “the good life” [12]. Wellbeing can also be defined as comprehensive consumption, which includes not only standard

marketed consumption goods but also includes, leisure, arts, health services, and environmental services provided by nature [13]. Comprehensive consumption can be considered as a function of comprehensive wealth, which comprises of capital stocks. Subjective wellbeing refers to positive and negative affect (positive affects refers to experiences of pleasant emotional states such as joy and peace and unpleasant emotional states such as fear and sadness), life satisfaction and eudaimonia (relates to the sense of purpose or value in one's life) [12].

Much of the current effort in studying wellbeing is in developing frameworks and defining and measuring wellbeing. There are many international frameworks available for wellbeing, including the Organisation for Economic Cooperation and Development's (OECD's) "How's Life?" framework and related Better Life Index (BLI) [14, 15], the United Nations Development Programme's human development index, and development against the United Nation's Sustainable Development Goals (UN SDG) [16, 17], The World Bank's Human Capital Index [18], and the New Economic Foundation's Happy Planet Index [19].

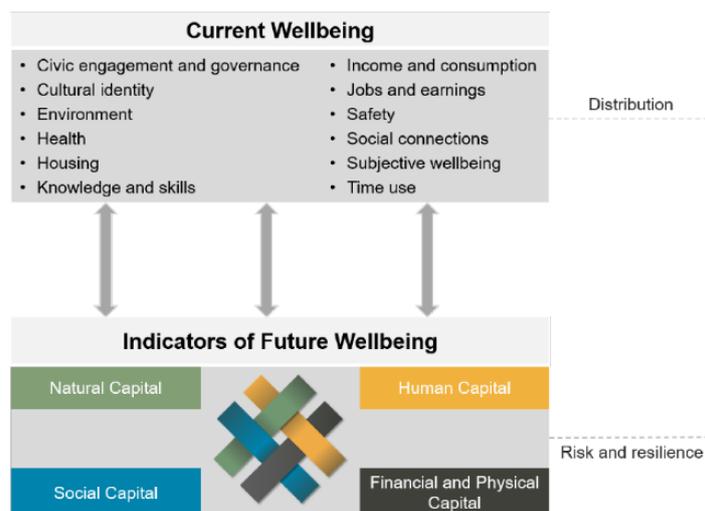


Figure 1. The Living Standards Framework. Adopted from Treasury [20].

Based on the earlier work by the OECD, the NZ Treasury has also developed the LSF for measuring and analysing intergenerational wellbeing, covering current wellbeing, future wellbeing, and risk and resilience across a range of economic, social and environmental domains [20]. Here, the intergenerational wellbeing can be defined as the discounted present value of the utilities derived by current and future generations from comprehensive consumption [13]. The LSF is a practical application of national and international research around measuring wellbeing. The LSF has been designed relevant to NZ circumstances and is applicable in the Treasury's policy advice work. To distil and structure this knowledge, and to ensure international compatibility, the NZ Treasury has used the OECD's approach. This framework looks not only at aggregate living standards but also at their distribution across the population. The sustainability of living standards for both present and future generations is a key part of the framework [21].

The elements of LSF, as shown in Figure 1, are the domain of current wellbeing, the capitals that combine to generate current and future wellbeing and risk and resilience.

The first element of the LSF is the current wellbeing of NZ, which is divided into 12 domains (as shown in Figure 1). These domains reflect wellbeing at a "point in time" and are based on research about what is important for people and their wellbeing [20]. The capitals are called capitals as they are the stock we use to produce the future flow of wellbeing [22].

The NZ Treasury recommended adopting the base wellbeing framework developed by the OECD with minor changes for the New Zealand context [23].

The third element of the LSF is risk and resilience. Risk and resilience directly relate to capital stocks. The number of capital stocks, which can be degraded or actively drawn down, influence the ability of people and the country to withstand shocks [21].

Though the NZ LSF (framework for thinking about wellbeing) and UN SDGs (set of goals) are different there is good alignment between the two [22]. Table 1 indicates the relationship that NZ Treasury has identified between NZ LSF 12 domains and capitals and the UN SDG. Note that only the primary relationship to SDG is indicated.

Table 1. Mapping Domains of NZ-Wellbeing to UN Sustainable Development Goals (SDG).
Adapted from Treasury Ormsby [22]

NZ LSF Wellbeing Domains	SDG
Civic Engagement and Governance	
Cultural Identity	None
Environment	     
Health	
Housing	
Knowledge and Skills	
Income and Consumption	 
Jobs and Earnings	
Safety	
Subjective Wellbeing	None
Social Connectedness	None
Time Use	None
NZ LSF Wellbeing Capitals	UN SDG
Natural Capital	  
Social Capital	 
Human Capital	 
Financial and Physical Capital	  

2.3. Modelling the Change in Wellbeing Using a Stock and Flows Technique

In the LSF, a ‘capital stocks and flows’ approach has been used as the basis. Here, stock can be defined as the quantity present at one specific time (or entities that can accumulate or deplete), and the flow variable is measured over an interval of time (about a year long time period) or flows are entities that make stocks increase or decrease.

As shown in Figure 1, this framework comprises four types of capital that are integral to current and future living standards. These four capital stocks represent the wealth of the country and interact to

generate beneficial flows (as shown in Figure 2). By using certain capital stocks and flows, other forms of capital (and flows) may be affected [21]. These may create a positive effect (increasing one stock of capital may lead to flows of services that benefit other forms of capital) or a negative effect (increasing one form of capital may undermine others) [21].

There has been significant econometric work looking at the interaction between two aspects at a time [12]. This could be the interaction between health and income or health and life satisfaction or education and social connection. This type of work is highly important for identifying the factors that contribute to different aspects of wellbeing and finding some of the connections between those different aspects [12]. However, such measurement does not let us experiment with different settings nor allow us to understand their interactions. Most of the current and historical work is theoretical and only brings one or two aspects of wellbeing together, most commonly growth or income and the environment [12].

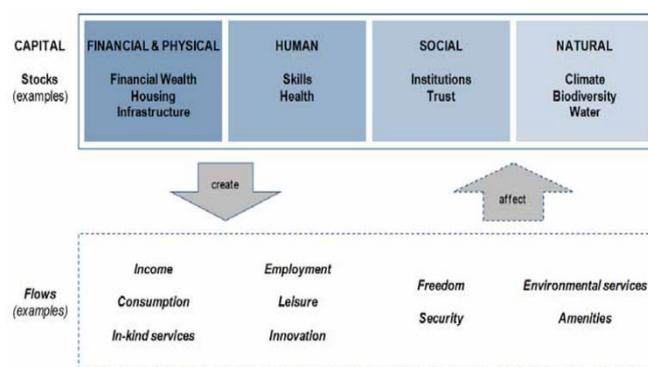


Figure 2. Treasury's Living Standard Framework. Adopted from King *et al.* [23]

However, a recently developed model by King [12], integrates environmental, social, and economic factors, and associated externalities, as essential and complementary influences on wellbeing [13]. This model includes all eleven aspects of OECD's "How's Life?" framework of wellbeing, and is intended for implementation in a computational form for use in policy analysis [12]. It is a top-down stock-and-flow model including a Computable General Equilibrium (CGE) model of an open economy [13]. This model details the behaviours of multiple household types, businesses, production processes, international linkages, and the role of government.

This model consists of sets of direct and indirect influences on wellbeing and their interactions. The direct influences of wellbeing are simply the eleven components of OECD BLI. These do not form a complete model of themselves. There are a number of supporting elements required to complete the model, as well as accommodating a variety of policy and other experiments within the model. This includes a production sector and a government sector, as well as the interactions with the rest of the world (such as migration) [13]. Many of the interactions between different influences on wellbeing occur in the "flow" equations of the model. These flow equations describe how the stocks (also called capitals) in the model change from one time period to the next, typically in response to changes in the stocks that relate to other influences on wellbeing [13].

The evolution of the components of the OECD BLI, obeys the standard equation of motion:

$$K_{t+1} = (1 - \delta)K_t + I_t$$

Where K_{t+1} represents a stock of main influences on wellbeing in this model (11 aspects of wellbeing according to OECD BLI) at time $t + 1$, K_t is the stock of main influences at time t , I_t is the aggregate of the flow during the time period t and δ is the natural rate of decline of the specific stock.

The interactions between the different influences on the wellbeing which occurs in the investment equation of the model can be shown by:

$$I_t = \sum_i \xi_i (N_t - N_{t-1})$$

Where N refers to each of the individual influences on wellbeing and ξ_i are their relative weights. The evolution of all of the main influences on wellbeing, as well as their impact on wellbeing follows the same structural form (as described in the above two equations).

3. Development of a Meso Level Performance Framework for Three Waters

3.1. Limitations of Current Frameworks for Infrastructure Decision-making

Infrastructure (i.e. transport, wastewater, water, energy) has been identified in studies as providing the fundamental services that contribute to human wellbeing and have over time been developed in a fragmented manner and mostly managed independently [24]. Investment assessments tend to utilise technical, financial, and environmental indicators that are easy to measure and have easily obtainable data sources, ignoring variables that are hard to show their impact, such as social and cultural outcomes [5, 6, 25].

The trade-offs between sustainable variables are hard to assess because it is more of a political process rather than a scientific process [25]. The Netherlands Scientific Council for Government Policy stated, “estimating environmental risks objectively or uniformly is not scientifically possible. To translate the concept of sustainability into an operative policy concept it is therefore necessary to make explicit normative choices in relation to identified risks and uncertainties” [26]. The United Nations World Commission on the Environment (The Brundtland Report) [27] indicated that there are limits to development, “not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities...sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life”.

Litman *et al.* [28] states in his work, “Sustainability planning is to development what preventive medicine is to health: it anticipates and manages problems rather than waiting for crises to develop. Sustainable development strives for an optimal balance between economic, social and ecological objectives.” Despite the growing interest in utilising sustainable variables and having consideration of the wellbeings in decision making few studies have provided a generic framework that can be used for wastewater, water or stormwater investment decision making [5]. Even fewer studies have tried to embed the use of social and cultural indicators. Another challenge in assessment approaches considering the wellbeing’s and capitals, is effectively considering indigenous values and their ancestral water rights [29].

3.2. Management Levels for Managing Wellbeing

When considering the development of a more holistic decision-making model for infrastructure, one needs to consider wellbeing from a wider perspective. The transference of capital (natural, human, built, or social capital) is limited by the finite resources of the world and society’s desire to elevate toward our ultimate end. For example, *Daly’s Hierarchy of Means and Ends* helps us to understand how the transferability of capital moves from the natural base (ultimate means), to built capital (intermediate means), to social capital (intermediate ends), and to our highest good or wellbeing (ultimate end) [29, 30]. The NZ LSF builds on this concept with the use of capital stocks and flows to help understand the impact of policy decisions on wellbeing along with understanding the level of risk and resilience of a people and country (Figure 1) [21]. The overall objective of the Treasury’s LSF is for measuring wellbeing outcomes and the capital stocks at a national or macro level. The wellbeing framework can also be used to analyse the impact of policies and support national budget decision-making. It is doubtful though whether the stock model would be appropriate at a meso and micro level given the scale and particular investment question at these levels.

An example of macro level policy decision making could be the overarching rules, funding, national budget planning, and reporting requirements etc. Whereas, at the meso level decision making can help design operational strategy, agency policy, and for helping local government to make long term and annual planning decisions for different utilities. At the micro level this policy decision making can help for service delivery, and evidence-based interventions etc. The interaction of the three levels is shown in Figure 3.

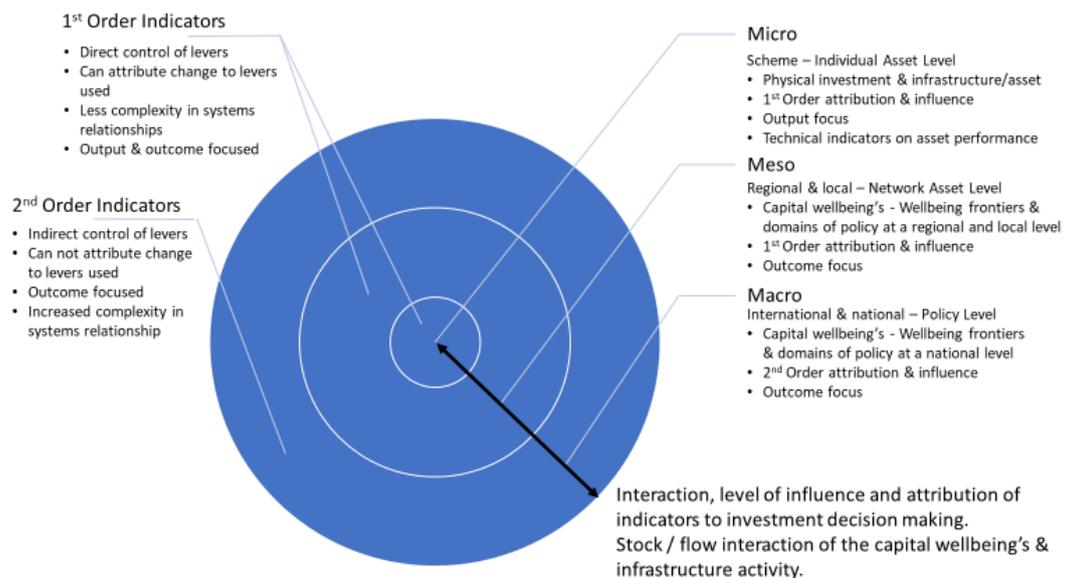


Figure 3. Macro, Meso, Micro levels for policy and infrastructure provision

3.3. Building a Meso Level Infrastructure Decision-Making Framework

Governmental frameworks such as the UN SDG, OECD's BLI, and NZ LSF focus on the providing guidance around the domains of wellbeing for macro policy level decision making [11, 13-15, 31], however their linkages to localised infrastructure development are weak.

In developing a meso level decision-making framework it is important to understand how we define both wellbeing as well as infrastructure services to start to shape a framework focused on regional/local policy direction, wellbeing outcomes, and infrastructure development. Otto *et al.* [24] define infrastructure services “as the provision of an option for activity by operating physical facilities and accompanying human systems to convert, store, and transmit flow entities.” This definition is useful in understanding how we link the technical aspects of infrastructure, the services they provide, and delivery of wellbeing outcomes utilising the stock flow model such as the NZ LSF.

The NZ LSF utilises the concepts developed by Karacaoglu *et al* [13] where the wellbeing capitals are developed within dimensions of a collective ‘wellbeing frontier’ containing the domains of public policy (see Figure 4). Through this model public policy aims to build intergenerational wellbeing through the capacity of the capitals to enhance the wellbeing frontier. The sustainability domain of the frontier links the other domains together leading to intergenerational wellbeing [13].

Karacaoglu *et al.* [13] also stipulate a shift in direction from looking for optimal policy solutions to building resiliency in sustainable outcomes. This moves our thinking from a focus on identifying the perfect solutions or policy direction that balances social, environmental, and economic outcomes to one that helps to nourish and build resilience to system shocks that threaten our wellbeing's and help us manage complexity and uncertainty [13] (see Figure 5).

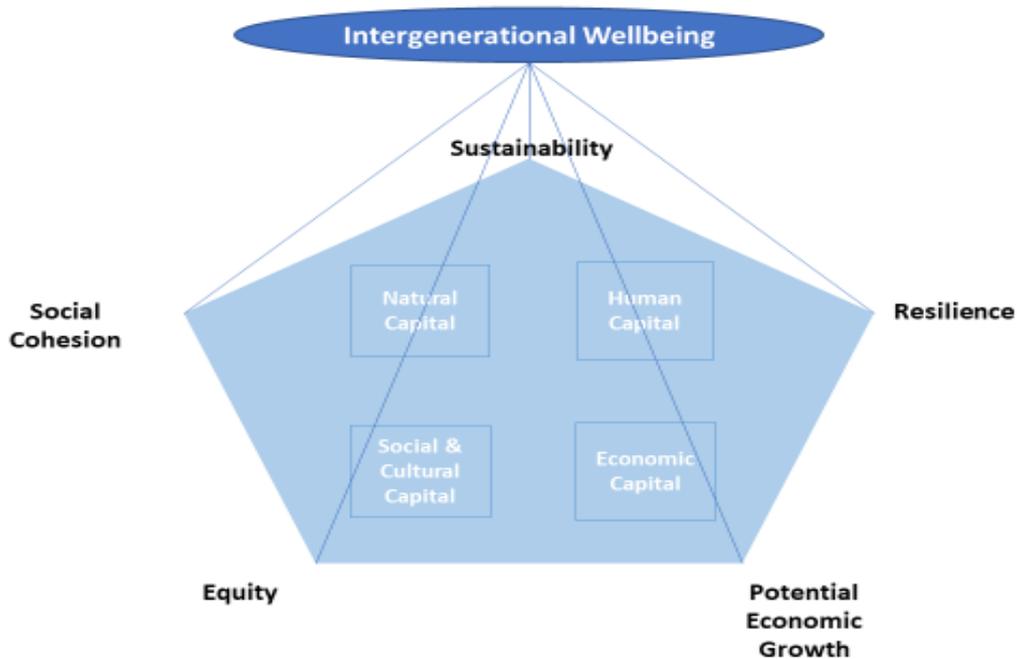


Figure 4. Wellbeing frontier. Adapted from Karacaoglu *et al.* [13]

To embed the wellbeing's into an infrastructure decision-making framework we need a more integrated approach that allows us to link the macro, meso, and micro interactions, and to consider the wellbeing frontier, the capitals, and the physical infrastructure and activity flows. The framework also needs to consider the growing uncertainty we are facing (i.e. climate change, technology, and growth pressures) and how we can enhance resilience.

A system-of-systems approach that considers the wellbeing frontiers, uncertainty and infrastructure is required to model the long-term infrastructure performance over a wide range of future conditions that can take into account the interdependencies of infrastructure services and the complexity of challenges from resource availability, diversification, technology, changes in socio-economic systems, and responses to climate change pressures [24, 25].

To fully understand the implications of our decisions we need to acknowledge the need to take technology into account in the assessment. Figure 6 shows the interaction of sustainable variables on infrastructure (technology); this form of sustainable technology does not threaten the quantity or quality of the resources.



Figure 5. Sustainability, resilience, and managing risk. Adapted from Karacaoglu, Krawczyk, and King [13]

Balkema *et al.* [25] notes that as the quantity and quality of the resources and the resilience of the environment change over time and space, the most sustainable technology solution will change accordingly. The study looked at assessing the sustainability of wastewater treatment systems considering exergy analysis, economic analysis, life cycle assessment, and general systems analysis [25].

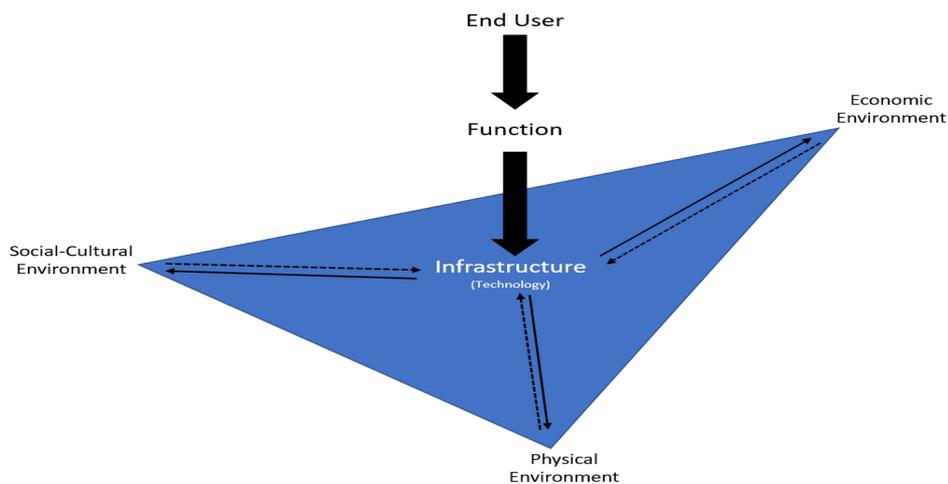


Figure 6. Infrastructure (technology) interacting with the environment. Adapted from Balkema *et al.* [25]

3.4. A Proposed Meso Level Infrastructure Decision-making Framework

A proposed framework has been developed for a meso level decision-making model for three waters infrastructure (drinking water, wastewater, and stormwater). The framework utilises the NZ LSF domains, UN SDG, the capitals, and integrates infrastructure (technology) together to help develop an investment decision-making model (see Figure 7; refer to Table 1 for NZ LSF / UN SDG linkages).



Figure 7. Meso Infrastructure Development Decision Making Framework (proposed).

The framework will need to be further refined and tested but is built on the understanding that a more comprehensive approach is required to better link infrastructure development decisions to the technology used, the impact on the capitals, regional/local policies, enhancement of resiliency and ultimately improved sustainability and intergenerational wellbeing.

4. Performance Measurements for a Meso Level Framework

The concept of wellbeing is complex, multi-faceted, and any indicators used to describe wellbeing are subject to value judgements and can make the underlying issues become clouded [23]. It is essential to consider the whole system using a multi-dimensional set of indicators to fully understand the integrated relationships and find where there may be gaps and potential solutions [25] and to consider the interaction of the indicators across the macro, meso, and micro levels (see Figure 3).

This helps to better understand the system's dynamics where one dimension leading to positive changes may have negative feedback loops creating unintended consequences in other areas. It also helps us to understand how the indicators can be used as the levers for change and to what level these levers can be directly or indirectly attributed to the infrastructure (technology).

The measurement and understanding of the wellbeing frontier also require the use of a systems approach as wellbeing is not linear or constant and its impact on today can be different when applied over time. Defining indicators is critical as the selection of sustainable solutions and outcomes is based on the indicators selected. While sustainable indicators give insight into the efficiency, the functional indicators determine the effectiveness of the solution. The functional indicators can also be considered the constraints on the system [25] helping set the level of stocks in the system.

A list of indicators has been identified for use in the meso level framework (see Table 2). The indicators have been aligned to the capitals, NZ LSF domains, and UN SDG's and indicate the level the indicators would be most appropriately utilised. They help define the interaction between the levels in the framework and if the indicator is of a 2nd order (indirect control of levers, cannot fully attribute change to the levers used, and outcome-focused; these indicators tend to be more focused on policy setting) or a 1st order (direct control of levers, can attribute change to levers used, both output and outcome focused; these indicators tend to be directly related to the infrastructure).

Table 2 was developed to show how the macro wellbeing frontier, in connection with the four capitals connects to the meso level. Indicators were identified through a search of international and New Zealand based literature to identify potential indicators that would help to understand the impacts on the system and allow for the future development of a meso level model. The OECD [4], NZ Treasury [3], and World Economic Forum [9] work were considered for indicators related to human and social capital, while work developed by the New Zealand Ministry for the Environment was considered in the development of indicators for cultural and environmental health of streams and waterways [1, 7]. Consideration of potential indicators of consumer perceptions of water were included [8] and work completed by the New Zealand Ministry of Health [2] and World Health Organisation [10] helped to identify potential indicators related to water and human health. This was rounded out with consideration of sustainable indicators developed for micro level infrastructure investment models [5, 6]. Indicators identified are a mix of qualitative and quantitative measures and have been developed to provide a wider breadth of understanding of the system dynamics when looking at the

Table 2. Meso level framework assessment of potential indicators [1-10]

Wellbeing & Infrastructure	Wellbeing Frontier		Indicators (potential)	Micro/Meso/Macro & Attribution (1 st or 2 nd order)
	NZ LSF Domains	UN SDG's		
Natural Capital	Environment		Environmental quality (pollution), Biodiversity, Natural resource depletion, Land use impacts, Ecosystem vulnerability, Conservation, Resilience (climate adaptation), Ability to support mahinga kai species (native food species), access to safe water/land	Macro Meso (1 st Order)
Social / Cultural Capital	Cultural Identity	None	Indigenous rights, Cultural acceptance, Satisfaction with access to natural environment and access to 3 waters	Macro
	Civic Engagement & Governance		Institutional trust, Participation / engagement, Satisfaction with decision making	Macro
	Social Connectedness	None	Belongingness, Migration, Resilience, Whanau (family) wellbeing, Access to suitable recreational grade monitored fresh/coastal swimming sites	Macro
Human Capital	Time Use	None	Generational relevancy	Macro
	Health		Life expectancy, Food availability, Infections / disease, Access to compliant drinking water, Access to wastewater services, Illness due to water borne infections, Notifications of non-compliance	Macro Meso (1 st Order)
	Housing		Affordability, Availability	Macro
	Knowledge & Skills		Training, Availability / ease of access, Qualification levels	Macro Meso (1 st Order)
	Safety		Crime, Safety, Corruption, Resilience	Macro
Economic Capital	Subjective wellbeing		Life satisfaction, Time availability, Poverty, Satisfaction, Inequality, Subjective satisfaction of water, wastewater, and storm water services	Macro
	Income & Consumption		GDP (National/Regional), Export / Import, Wealth	Macro
Infrastructure (Technology)	Jobs & Earnings		Employment- availability/growth/diversity, Unemployment, Cost of labor, Earnings, House ownership, Organisational balance statement (debt & investment levels, Productivity, Job satisfaction, Strain/stress, mean equalized household disposable income & household income	Macro Meso (1 st Order)
	Physical		Lifecycle / asset preservation, Capacity, Resilience, Affordability, Adaptability/flexibility, Emissions, Net present value, Cost benefit, Operating ratio (annual operating revenues to annual operating expenses)	Macro Meso (1 st Order) Micro (1 st Order)

interrelationships between the macro, meso, and micro levels. This initial work will allow for the future development and integration of the macro analysis model with micro level influences on the meso level. This in turn will help to understand the level of resilience in the system through the stock/flow modelling and the influence and attribution of the indicators on decision making for today and the future.

5. Conclusions

Significant work has occurred in the development of macro level wellbeing frameworks to support policy setting at the national level. The development of a meso level wellbeing framework and a suite of indicators that will integrate with macro and micro levels will provide a valuable resource for decision makers when considering investments in three waters infrastructure. This paper has identified the value of utilising a framework like the NZ LSF and how it could be integrated with the UN SDG for use at a regional/local level to understand the most appropriate three waters infrastructure solution and the impact for intergenerational wellbeing. This is only the first step in the development journey with further work required to explore the concepts further and better define the interactions, systems dynamics, modeling, and indicators that can be utilised to understand the current and future state of wellbeing.

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