What's WESWI?

Chris Batstone[1], Jonathan Moores[2], Mark Newton[1], Sharleen Yalden[2]

1. Cawthron Institute
2. National Institute of Water and Atmospheric Research (NIWA)

Abstract

The acronym WESWI represents Waterbody Ecosystem Services Wellbeing Index. WESWI is designed to assist urban collaborative process decision makers weigh the trade-offs between the wellbeing associated with employment, housing and industry contribution to regional value added income, and that associated with the ecosystem services delivered by freshwater and coastal waterbodies impacted by urban development. We examine the use of WESWI in an urban development case study located on the urban fringe of Auckland City. We show how WESWI can used to understand the effects of contrasting urban stormwater management scenarios on the wellbeing associated with ecosystem service provision by an urban stream.

Keywords: Ecosystem services; urban development, water sensitive design, wellbeing

Corresponding author: Chris Batstone

chris.batstone@cawthron.org.nz

Introduction

In urban water quality collaborative processes decision makers weigh the trade-offs between the wellbeing associated with employment, housing and industry contribution to regional value added income, and that associated with the ecosystem services delivered by freshwater and coastal waterbodies impacted by urban development. They are usually citizens as opposed to technical experts, often preferring cost effectiveness analyses over cost benefit analyses because while costs of specific courses of action are readily available, monetization of the benefits of alternative projects may be less appropriate for the environmental decision context (Murray, 2013). They are sometimes wary of purely economic analyses, yet could benefit from a metric to understand the wellbeing changes, understood by the environmental economics profession as monetised benefits or losses, associated with their aspirations for the condition of waterbodies under differing scenarios.

WESWI was designed to provide that metric. The acronym WESWI represents Waterbody Ecosystem Services Wellbeing Index. In this paper we will describe the research and decision contexts, the development of WESWI, and illustrate its application in a case study in one of Auckland's urban fringe catchments. In the subsequent section, Methods, we describe the Urban Planning that Sustains Waterbodies (UPSW) decision support system (DSS) and the WESWI metric that informs the social wellbeing indicator. We describe how the index is constructed and the data collection process that sits behind it. In the case study section we describe application of the UPSW DSS to the freshwater receiving waterbodies of urban and rural stormwater in the Lucas Creek catchments of on Auckland's North Shore. These results are followed by a discussion and concluding remarks.

Methods

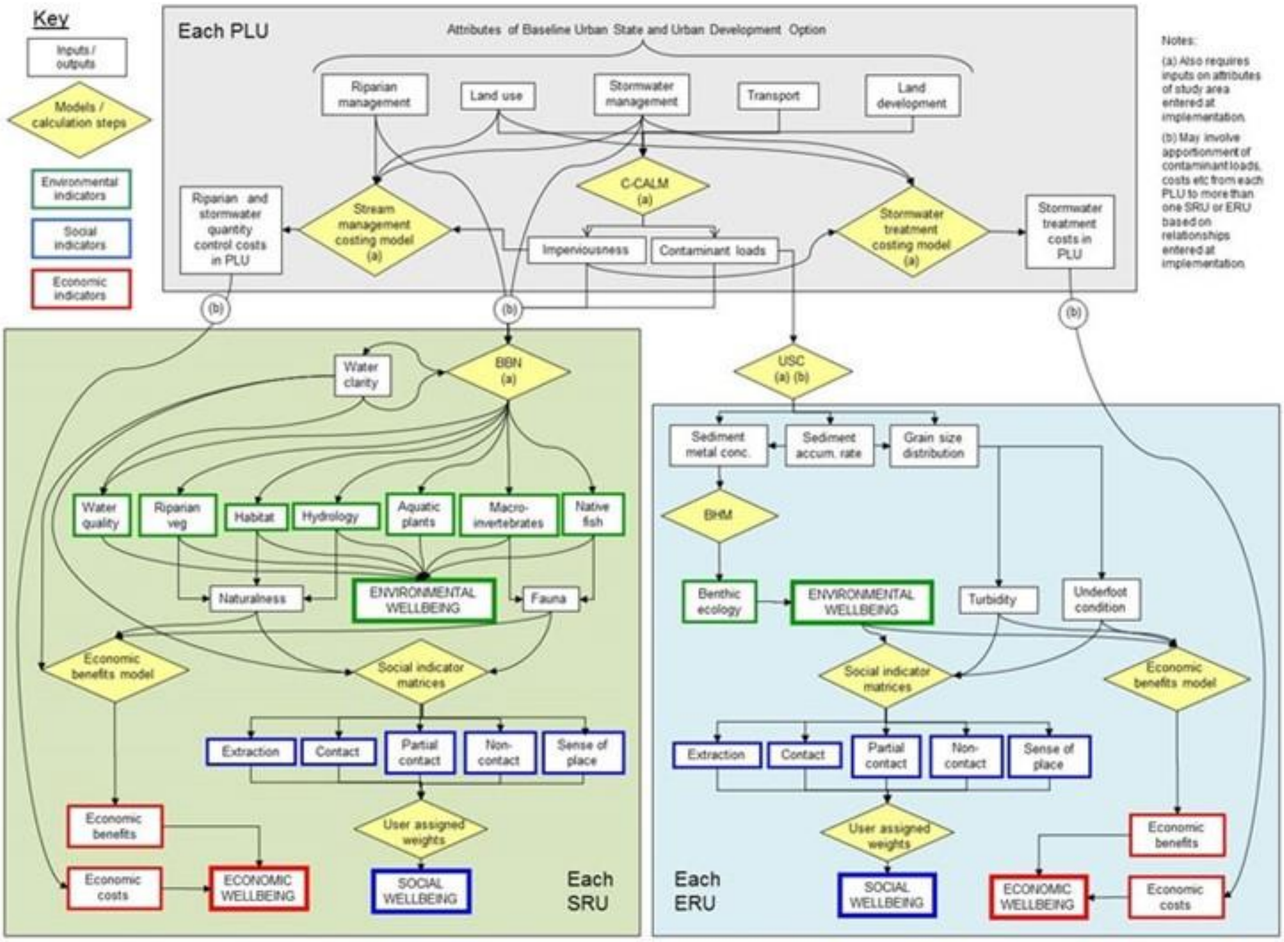
The UPSW DSS

The UPSW DSS spans the urban catchment social-ecological system. It is a spatial system in the sense that it operates at the sub-catchment level with catchments divided into relatively homogeneous areas termed planning units (PLUs). Corresponding reporting units that give spatial expression to the waterbody effects of development and stormwater management are termed Stream Reporting Units (SRU) and Estuary Reporting Units (ERU). Changes to the biophysical characteristics of urban streams have consequences for the level of stream ecosystem service provision. In turn this impacts the level of wellbeing experienced by the community. In the UPSW DSS those changes in community wellbeing are expressed in a composite indicator framework as indicators of economic and social wellbeing derived from provisioning and cultural ecosystem service delivery. Consideration of the economic wellbeing indicator outcomes generally, and outcomes in the ERUs, are beyond the scope of this paper, and will reported elsewhere.

The architecture of the DSS is based in OECD statistics Directorate Composite Indicator Methodology (Nardo et al., 2006). While inputs to the DSS come from the urban catchment social-ecological system (catchment land use, for example), the reporting of indicators is confined to the part of the system bounded by the waterbody riparian margins (stream water quality, for example). Figure 1 describes the DSS structure.

Experienced preference data (aka experienced utility reflected in experienced satisfaction) derived from expert workshops are used to model changes in social wellbeing. This is assessed through the Waterbody Ecosystem Services Wellbeing Index (WESWI) which reflects the varying capacity for communities to participate in relationships with urban waterbodies. In the DSS WESWI is modelled as a function of three key biophysical variables: water clarity, fauna and naturalness. These three variables align with attributes of the same names. They are a reduced set of the five attributes developed by Kerr and Sharp (2003) for an offset mitigation analysis of the Lucas Creek catchment. These five attributes influencing preferences in relation to urban streams are predicted (or could be predicted from other outputs of) the stream Bayesian Belief Network (BBN) model incorporated in the DSS,

Figure 1: Architecture of the UPSW DSS (Source: Moores et al., 2014)



The Social Wellbeing Indicator

In the UPSW DSS social wellbeing is understood in terms of the capacity (Sen, 2008) for communities to derive wellbeing from their relationships with freshwater. As provisioning and cultural ecosystem provision by waterbodies changes, so does that capacity to derive wellbeing from those relationships. Degraded or improved ecosystems are logically associated with degraded or improved wellbeing. The Waterbody Ecosystem Services Wellbeing Index (WESWI) has been developed to assess these changes.

The assessment of WESWI involves empirically-based and probabilistic methods that predict a number of use and non-use values of urban waterbodies based on two sets of environmental attributes, one set each for streams and estuaries. A series of matrices predict scores for extraction (fishing, harvesting and provision services), contact, partial contact and non-contact activities (as categories of activities enabled by differing levels of ecosystem services), and place satisfaction in each SRU and ERU. This approach is based on the notion of water quality categories that reflect enhancements to ecosystem services (Van Houten et al. 2007) and are used in the prediction of social wellbeing.

Inputs to the WESWI matrices for the SRU matrices are: water clarity, 'naturalness' (calculated from the BBN-generated indicators riparian vegetation, habitat and hydrology) and 'fauna' (calculated from the BBN-generated indicators macro-invertebrates and native fish). The outputs are scores on the scale 0-10 in each SRU and ERU for each of the five WESWI relationships: extraction, contact recreation, partial contact recreation, non-contact recreation and place satisfaction.

WESWI and its contributing precursors are assessments of the state of the system in social wellbeing terms. Through those elements it embraces use and non-use values and sense of place, defined as a multi-dimensional construct that embraces cognitive, affective and conative relationships with the streams and estuaries (Jorgensen et al., 2001).

The development of these methods was founded on the notion that the environmental attributes used to derive estimates of WTP in the choice experiments that provide the data that inform the economic wellbeing indicator could also be used as a basis for predicting the suitability of estuarine and freshwater waterbodies for the specific activities described above (Batstone et al., 2013). Expert elicitation methods (Burgman, 2005; Burgman et al. 2011) were used at focus group sessions held in Auckland and Christchurch to develop and trial a visual analogue method to derive assessments of the experienced utility (aka experienced preference) (Kahneman and Sugden, 2005, Hajkowicz et al. 2008) effects of changes to these environmental qualities. More recent literature (Welsch 2014a; 2014b) uses the term experienced preference to frame the experienced utility concept. The authors understand this application of the experienced preference concept at the micro level is novel, and is as yet unpublished in the economics literature beyond current conference publications (Batstone et al. 2013; Batstone et al. 2015).

Attendees at the focus groups were members of the public selected by a market research company as being broadly representative of the wider urban population, while also being known to take part in water-based activities. The attendees were asked individually to identify best, worst, and most frequently encountered scenarios of the attribute combinations, then assign scores to combinations of varying quality (high, medium, low) in environmental attributes for specified types of activity and for one non-use category (sense of place). The number of attributes was limited to three because of the cognitive difficulties of representing and attempting to assign scores to combinations of any greater number of attributes. This led to the consolidation of stream attributes previously used in the stream choice experiments (from five to three, as noted above). The results of the focus group sessions were used to derive weighted-average scores for each combination of attribute quality that are assumed to be representative of the wider urban population.

Respondents made their own assessments of the reliability of their responses through a ten-point scale. This information was used to identify and exclude potentially unreliable scores (reliability less than 8 out of 10). These estimated relationships between the attribute sets and representative experienced utility scores have been used to populate a series of look-up tables. Each indicator score is calculated by querying these tables based on the predicted values for each of the three attributes in the SRU and ERU attribute sets, respectively to derive the WESWI for each five classes of relationships with waterbodies.

Changes to the WESWI reflect the changes in wellbeing that are driven by changes created by the effects of the combination of urban stormwater and various mitigation strategies. The WESWI maps changes in satisfaction scores for each of the five activity classes as urban stormwater influences water and ecological qualities of freshwater bodies, which in turn impact combinations of the key connecting attributes influential on ecosystem service provision. A weighting system in the architecture of the UPSW DSS allows weights to be assigned to the various classes of waterbody relationship so that the overall wellbeing indicator reflects only those activities and the ecosystem services that are relevant for each waterbody.

The social wellbeing indicator is intended to produce complimentary information to the economic benefits indicator. While it is driven by the same underlying biophysical variables, its information basis is different (experienced preference cf decision utility: Welsch 2104a, 2014b)), collected from a contrasting sample and data collection (expert workshop cf census demographic survey). It provides additional information to the benefits indicator in that it develops information as to the source of changes in wellbeing that motivate summary monetised estimates that lie behind the WESWI.

The Lucas Creek Catchment Case Study

The Lucas Creek Catchment

Located on Auckland’s northern urban fringe, the Lucas Creek catchment has undergone partial development since the 1980s. Auckland Council supplied information on projected future increases in population, dwellings, and land use change. It has the advantage of a case study location in that it features sub-catchments with contrasting characteristics, making it a good fit to deal with questions of whether stream water quality can be maintained and improved in different urban settings, and how the various combinations of urban development options and stormwater mitigation scenarios impact wellbeing as assessed by WESWI. Figure 2 describes the case study location including information identifying the two sub-catchments of Lucas Stream (PLU 2) and Oteha Stream (PLU 3), and the apportionment of sub catchment level PLUs and SRUs. In considering the WESWI outcomes, the focus is on the Lucas Stream and Oteha Stream sub-catchment as these contain the more significant streams in the sub-catchment (Moores et al., 2012).

Figure 2: Case Study Location (Source: Moores et al., 2012).

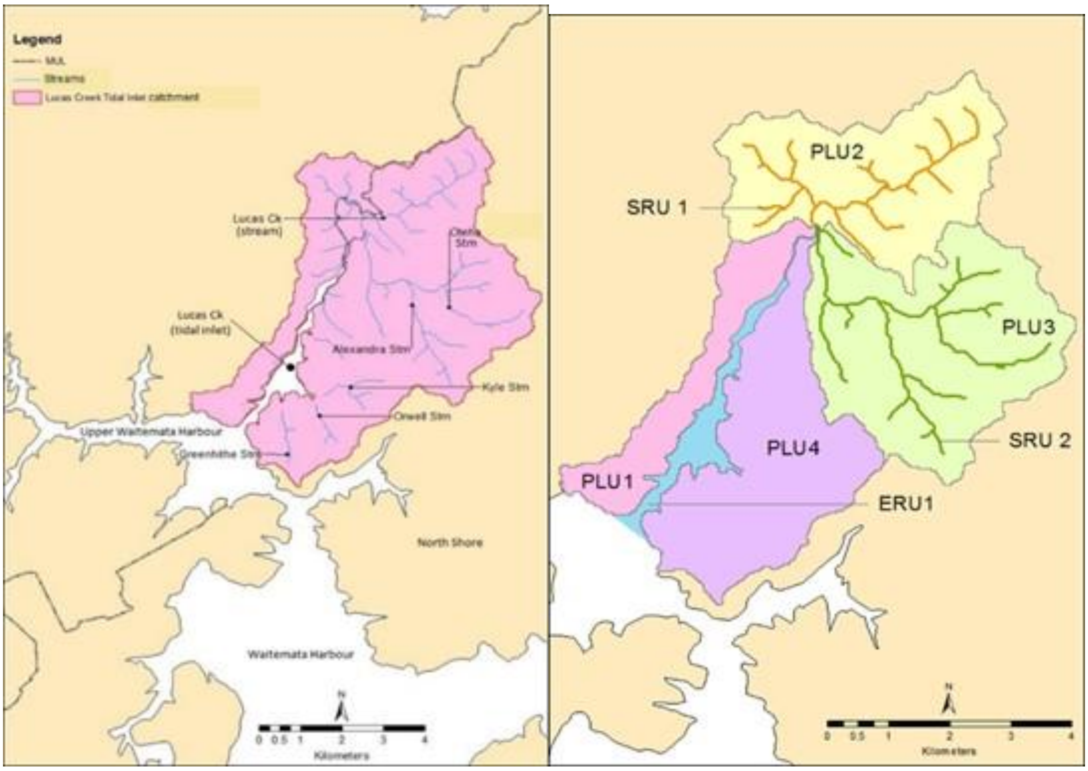
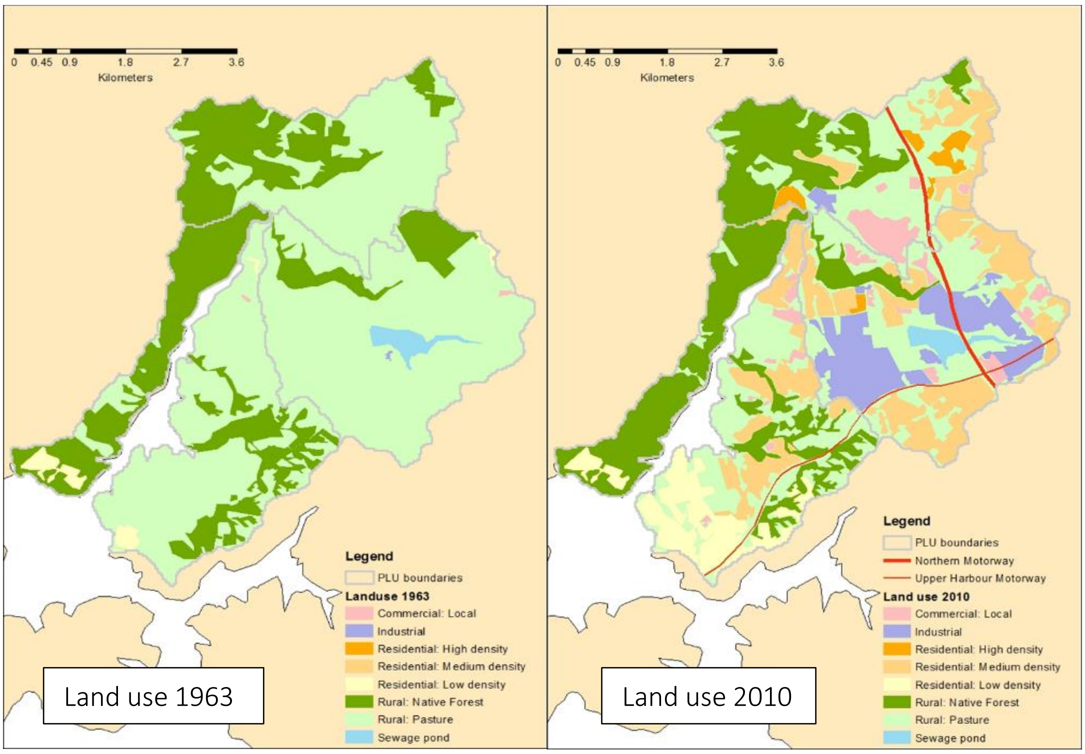


Figure 3 describes land-use changes in the catchment for the period 1960 – 2010. Note the differing type and extent of historic development in these two sub-catchments: the Oteha Stream catchment is more developed and contains most of the industrial land use in the catchment as a whole.

Figure 3: Land use changes 1960 – 2010 (Source: Moores et al., 2012).



Scenario development

Scenario development begins with consideration of two baselines to allow comparison of hypothetical fully greenfield development scenarios with partial greenfield and brownfield scenarios, while holding all else constant. The five future land development scenarios vary by intensity of development. Three start from the position of historic development. Two start from the hypothetical position of there being no prior development. The adoption of these two starting points enables outcomes influenced by the legacy effects of historic urban development to be compared with those in which there were no legacy effects.

Scenarios 1 – 3 feature the first baseline with historic catchment development:

<u>Scenario 1:</u>

'Status quo' low density greenfield development: additional dwelling numbers, types and location consistent with Auckland Council projections

<u>Scenario 2:</u>

Higher density development: a mix of greenfield land and infill in existing residential areas

<u>Scenario 3:</u>

Brownfield development: higher density residential development replacing areas of existing industrial development

Scenarios 4 and 5 address the second baseline - no previous development:

<u>Scenario 4:</u>

Low density greenfield development: projected dwelling numbers accommodated by low density forms of development

<u>Scenario 5:</u>

Higher density greenfield development: projected dwelling numbers accommodated by higher density forms of development

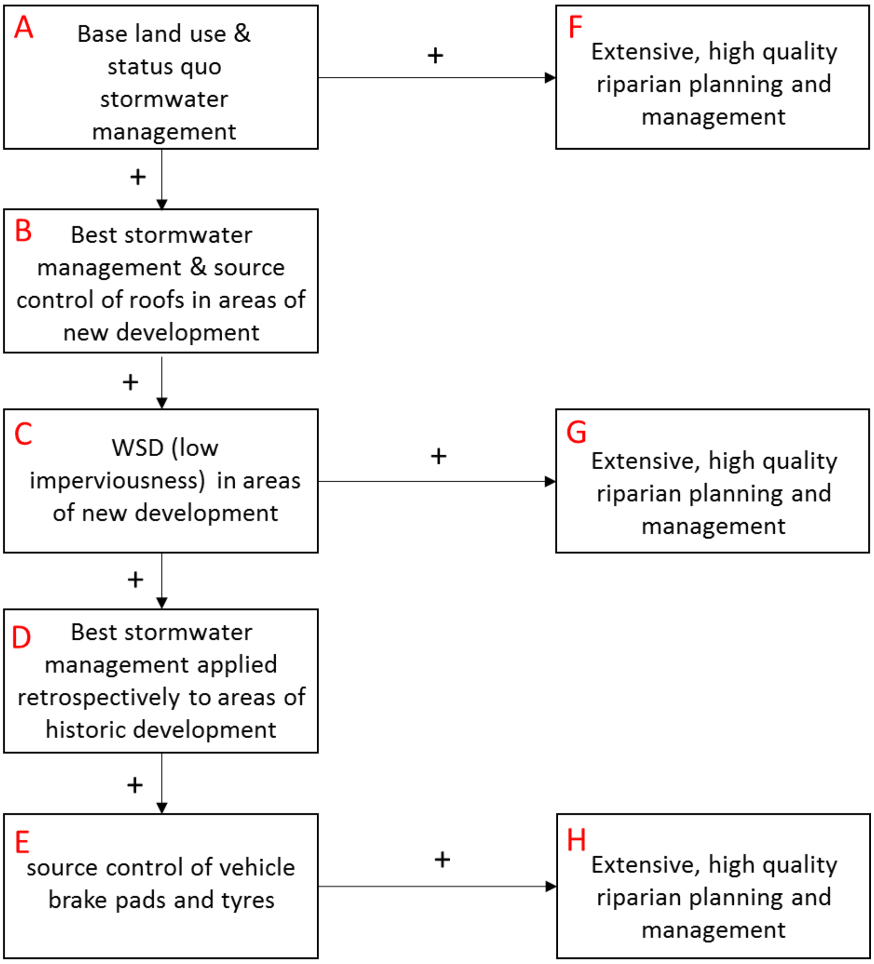
Up to eight variants of each land development scenario were modelled. A range of stormwater contaminant management strategies were considered in additive fashion. Riparian management was considered in addition to varying levels of contaminant management, modelled as the marginal planting of 90% of stream length. Figure 4 describes the sequence of stormwater mitigation scenarios.

Among these mitigation strategies are a number that are considered Water Sensitive Design options (WSD). Water-Sensitive Urban Design (WSUD, WSD) is an approach to water resource management in urban environments that addresses both water quantity and water quality issues. WSUD/WSD integrates natural water systems with built form and landscapes and promotes a more resourceful use of water. Key elements include: working with nature; avoiding or minimising impervious surfaces; and utilising vegetation to assist in trapping sediment and pollutants. (Wellington City Council, 2014).

WESWI Outcomes

The UPSW DSS considers changes in wellbeing arising from provisioning and cultural ecosystem service provision changes in five classes of relationship with urban waterbodies and their riparian margins: non-contact (e.g. walking), partial contact (e.g. boating), full contact (e.g. swimming), provisioning (e.g. fishing) and sense of place, understood as place satisfaction. The information presented in this paper focuses on non-contact and place satisfaction relationships because the other three relationship classes are of limited relevance to this case study catchment: there are few opportunities for swimming, fishing and boating in these streams.

Figure 4: Additive stormwater contaminant management scenarios.

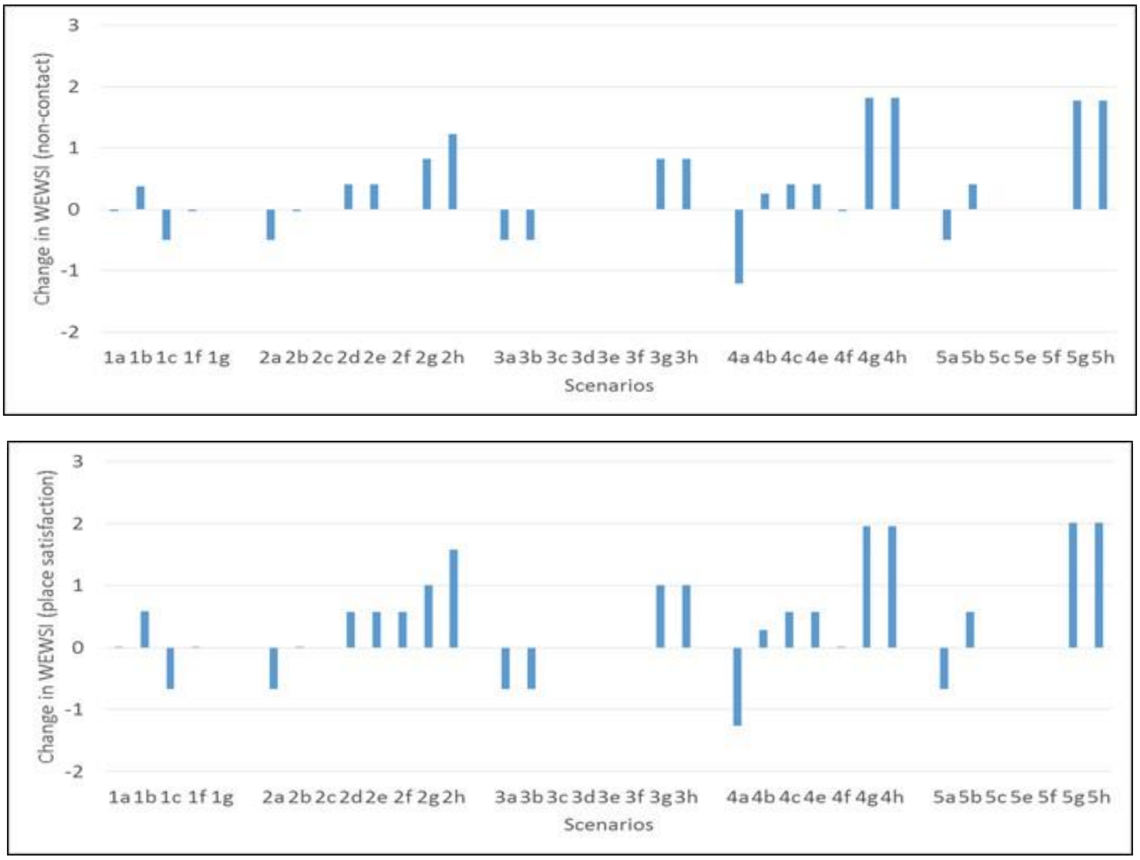


In those relationships wellbeing, reflected in aggregated experienced preference scores over the interval (0…10) is modelled as a function of water clarity, fauna and naturalness where the attribute fauna is a function of the biophysical macroinvertebrates and native fish scores, and the naturalness attribute is a function of the riparian, instream habitat, and hydrology scores.

At the beginning of each development scenario the waterbody under consideration is in a biophysical condition that enables particular levels of cultural ecosystem service provision which in turn are reflected in the indicator's experienced preference scores. Over the 50 year horizon of the study the underlying attributes are influenced by the combination of development and mitigation scenarios resulting in contrasting changes to the biophysical scores, reflected in modified cultural ecosystem service provision, and in turn experienced preference scores (WESWI). The data presented in the charts in this section reflect the net change in scores between the onset and completion of the scenario time span.

Figures 5 and 6 describe the effects of catchment development scenarios on wellbeing through depiction of changes to the WESWI for non-contact and place satisfaction relationships for Lucas Stream and Oteha Stream, respectively.

Figure 5: – Change in WESWI scores for non-contact (upper) and place satisfaction (lower) relationships, Lucas Stream by mitigation scenario.



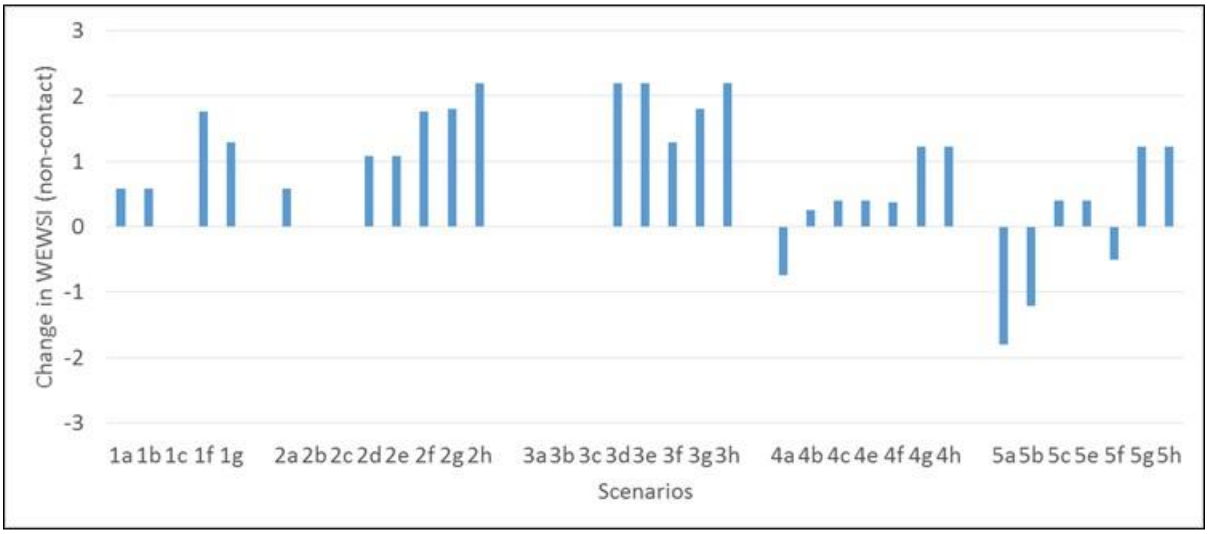
Land development: ND = no development
(1) Historic + low density
(2) Historic + high density
(3) Historic + brownfield
(4) Greenfield low density
(5) Greenfield high density

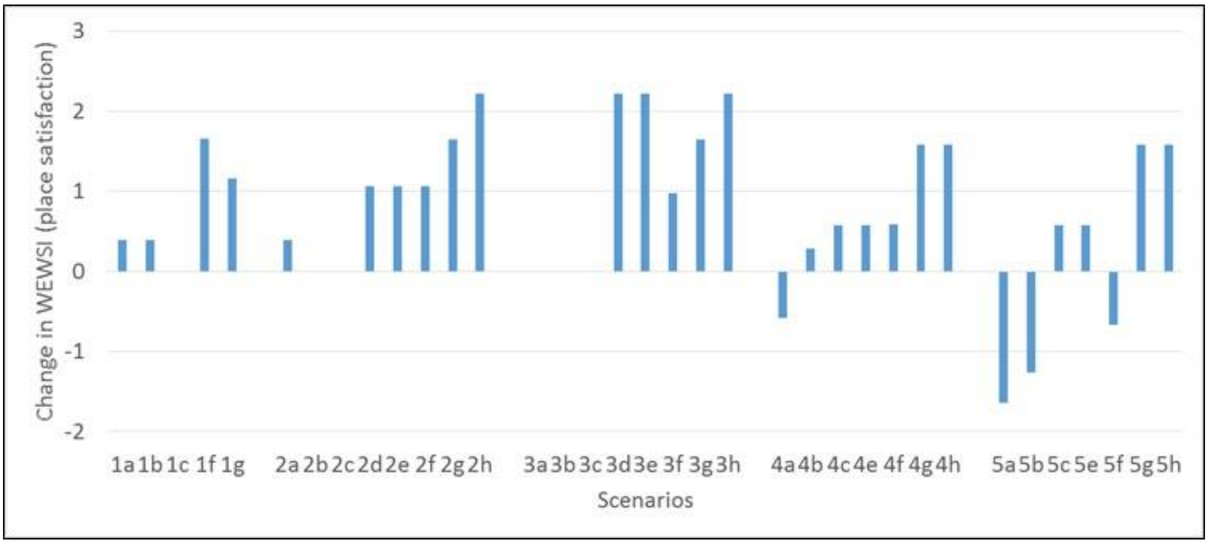
Mitigation: (A) Status quo contaminant controls
(B) Best practice contaminant controls
(C) As (B) with Water Sensitive Design (lower imperviousness)
(D) As (C) with retrofitted stormwater
(F) As (A) with riparian planting
(G) As (C) with riparian planting
(H) As (D) with riparian planting

Common to both Lucas Creek and Oteha Stream across both non-contact and place satisfaction, changes to WESWI scores are: highest with riparian planting (scenarios G and H) because of influence on naturalness and fauna; lowest where there is no riparian planting and status quo contaminant controls (scenarios A); and, higher with the addition of higher levels of contaminant controls than with status quo controls (B, C, D, E versus A) because of the influence on water clarity and to a lesser extent fauna.

There are some apparent anomalies present: the reduced urban footprint of WSD is modelled to have the unintended consequence of generating higher rural sediment loads, which influences clarity and in some scenarios this counteracts the other model precursors so that WSD scores are lower than those for equivalent non-WSD scenarios (1C v 1B in both streams, 5C v 5B in Lucas Stream). Where there is no bar there has been no change in the WESWI score.

Figure 6: Change in WESWI for non-contact (upper) and place satisfaction (lower) relationships, Oteha Stream by mitigation scenario.





Land development:	ND = no development (1) Historic + low density (2) Historic + high density	(3) Historic + brownfield (4) Greenfield low density (5) Greenfield high density
Mitigation:	(A) Status quo contaminant controls (B) Best practice contaminant controls (C) As (B) with Water Sensitive Design (lower imperviousness) (D) As (C) with retrofitted stormwater	(F) As (A) with riparian planting (G) As (C) with riparian planting (H) As (D) with riparian planting

Another interesting feature of the results for Oteha Stream is that with brownfields development the scores with the highest levels of contaminant control are the same with and without riparian planting (3E v 3H). Given that most of the brownfield development happens in this SRU, this indicates that high levels of contaminant control alone make a big difference to the precursor variables. Any additional improvement deriving from riparian planting doesn't appear to lift the WESWI into a higher category. This is likely to be an artefact of the way the UPSW tool is configured. The WESWI scores are determined by the levels of biophysical precursor scores (fauna, naturalness and water clarity). The tool accesses lookup tables containing these scores which are expressed in defined categories. The specification of category boundaries may mean in some instances the tool is not sensitive to small improvements in the levels of the precursor scores, contributing to a “stickiness” in the movement of the WESWI scores.

Discussion

Background to Discussion / Summary of Results

Results have been presented for changes to social wellbeing that accompany alternate mitigation strategies based on indicators relating to non-contact and place satisfaction relationships with streams.

The WESWI scores are generally highest where high levels of contaminant management combine with riparian planting, because of the influence on naturalness and faunal considerations. WESWI scores are generally higher with the addition of higher levels of contaminant controls than with status quo levels because of the influence on water clarity, and, to a lesser extent faunal considerations. Wellbeing scores are generally lowest where there is no riparian planting and only status quo contaminant controls are included.

Because of an assumption that Water Sensitive Design (WSD) results in a reduced urban footprint, WSD is modelled to have the unintended consequence of generating higher rural sediment loads than equivalent non-WSD development scenarios. This in turn influences water clarity and in some scenarios this counteracts the other precursors so that WSD scores lower than equivalent non-WSD scenarios in terms of the WESWI scores.

The UPSW DSS produces indicators of water quality in both physico-chemical and ecological terms. The physico-chemical indicator water quality indicator integrates the comparison of a range of attributes, including water temperature, clarity, dissolved oxygen, nutrients and toxicants, against guideline values; the ecological water quality indicator is constructed as an indicator of the potential abundance and diversity of macroinvertebrate species, based on stream water quality, physical habitat, and riparian condition.

Relationships between WESWI and Other Indicators

The UPSW DSS produces a range of information including total estimated monetised benefits, WESWI change scores, and change in the two water quality scores associated with each mitigation scenario. In order to establish the nature of the relationships between the ecological water quality score, bivariate ordinary least squares (OLS) analysis was conducted over the data generated from the implementation of the UPSW DSS. Examination of the residual plots from the model estimations shows no sign of the patterns indicative of heteroscedasticity. Most relevant to this discussion is the strength of the correlations between WESWI and the monetised benefit and the ecological water quality indicators. The ecological score is preferred because it captures the physico-chemical influences that influence the "life" of the stream that are also influenced by riparian effects. Table 1 summarises these outcomes (Batstone and Moores, 2015).

Table 1: Bivariate relationships between selected UPSW DSS output indicator scores, Source: (Batstone and Moores, 2016).

Model	Coefficient Estimate	R sq	P-value
MBI = f (WESWI _ Non-contact)	5,064,594.73	0.90	< 0.01
MBI = f (WESWI _ Place)	4,875,308.35	0.89	< 0.01
dWESWI_NC =f (dWQ)	1.63	0.38	0.03
dWESWI_Place =f (dWQ)	2.09	0.47	< 0.01

Key: MBI[1] = Monetised benefit indicator; dWQ = change in macroinvertebrate water quality indicator score; dWESW_NC = WESWI non-contact; dWESWI_Place = WESWI place satisfaction.

These are expected outcomes in that: (1) the economic benefits, WESWI and water quality scores are a function of the same three precursors. The monetised benefits indicator is highly correlated with the WESWI scores; and changes to the WESWI scores are statistically correlated with changes in the ecological water quality score. The lower explanatory power of the WESWI / water quality scores may be attributable to the fact that the variables are expressed as changes, and in the case of the non-contact scores, water quality per se is likely to have less impact on the satisfaction accruing to relationships that do not involve harvesting or immersion. The difference in explanatory power between the non-contact and place satisfaction water quality models may be an artefact of the contribution of extensive riparian planting to improvements in water reflected in the ecological water quality index.

Influence of Mitigation on WESWI

Improvements in WESI reflect variations in the effectiveness of the different stormwater controls at reducing contaminant loads associated with urban development – zinc, copper, lead and sediment. WESWI changes are greater with the addition of an increasing number of stormwater controls. Riparian planting makes a marked difference to WESWI over that achieved by stormwater controls alone.

Changes in WESWI scores are correlated with changes in the water quality metric that respond to variations in the effectiveness of stormwater controls. The WESWI indicator is designed to reflect wellbeing changes understood as the capacity for the community to participate in relationships they value with waterbodies. Wellbeing derived from ecosystem service provision by streams is a function of the combination of development and stormwater mitigation scenarios. Further, the greatest potential to maintain and enhance that wellbeing is to be found when collaborative decision makers adopt strategies that emphasise riparian

[1] The MBI is based in the same three precursor attributes as WESWI. The estimated monetary value of changes to those attributes is derived by benefit transfer from an offset mitigation assessment project reported in Kerr and Sharp (2003) undertaken in the Lucas Creek Catchment for Auckland Regional Council.

planting and the strongest forms of source control and treatment of stormwater volumes and contaminants.

Limitations of WESWI and Further Work

The information presented in this paper demonstrates the potential for the UPSW DSS socio-economic indicators to provide complementary sources of information for decision making around selection of urban catchment development mitigation strategies. However, the advantages of including socio-economic indicators need to be considered in the light of a number of important limitations associated with their creation and use.

Strengths of the DSS lie in its ability to span the catchment social-ecological system and to provide forecasts of the likely future state of urban streams. The same precursors that inform stream water quality measures (physico-chemical and ecological health) also provide the connections with the socio-economic system. The connection lies in linkages between ecological health, the level of cultural ecosystem services provision, and changes in social wellbeing reflected in the social wellbeing index WESWI.

The limitations of the use of UPSW DSS WESWI indicator lies in uncertainty that arises from a number of areas. Development of the WESWI method of assessing changes in wellbeing associated with stream ecosystem service provision remains incomplete; it is novel and yet to be peer reviewed through journal publication. WESWI scores are calculated on a per waterbody basis: there is no opportunity to take account of physical scale, for example the length of a stream. This an opportunity for development. The look up tables of WESWI scores contained in the DSS are to date based on a single data collection exercise based in one location and these scores may not be transferable to other locations. Work is in progress to refine the data collection process by investigating an on-line survey tool, and the use of "expert" ecosystem services consumers as opposed to representative samples in the elicitation workshops.

Concluding remarks

The sometimes non-technical members of the general public who populate the collaborative governance processes employed in water quality management in New Zealand are often wary of purely economic analyses. Deliberations on aspirations for the condition of the waterbodies under their consideration would benefit from a socio-economic metric to understand the wellbeing changes associated with differing mitigation scenarios based in combinations of urban development scenarios and various mitigation strategies. WESWI was designed to provide that metric. The acronym "WESWI" represents Waterbody Ecosystem Services Wellbeing Index.

The paper describes the application of the Urban Planning that Sustains Waterbodies Decision Support System to a mixed land-use catchment in the Auckland Council jurisdiction to evaluate the potential for various combinations of development and stormwater management to maintain or improve water quality of urban streams. It reports the changes in wellbeing assessed by the WESWI induced by stream water quality changes in, and beyond status quo management scenarios. Statistically significant bivariate relationships between WESWI changes and changes in an ecological water quality indicator, and a monetised benefits indicator have been identified in this analysis.

The various wellbeing outcomes reflected in the WESWI are associated with changes in the water quality metric. In varying degrees the effectiveness of stormwater controls in combination with a number of alternative urban development prescriptions motivate changes in these indices. Under status quo development proposals, wellbeing is reduced without mitigation. Higher levels of contaminant controls than with status quo methods produce greater increases in the WESWI. The greatest increases in wellbeing occur in the scenarios that feature WSD strategies and extensive riparian planting.

Acknowledgements

This UPSW research project is funded by the New Zealand Ministry for Business, Innovation and Employment (MBIE) as part of the Resilient Urban Futures (RUF) Programme.

Auckland Council has provided in kind support for the project, through involvement of council staff in the development and application of the DSS.

References

Batstone, CJ, Moores, J., Baines J., and S. Harper, 2013, An investigation into the use of experienced utility scores to assess multi-attribute changes in environmental quality. On-line Proceedings of the 57th annual Australian Agricultural and Resource Economists Society Conference, Sydney, NSW, Australia Feb 5-8th 2013

Batstone, CJ, Yalden, S., Moores, J., and M. Newton 2015, On the use of experienced preference data as indicators of thresholds of potential concern in linked coastal social-ecological systems. On-line Proceedings of the 59th Annual AARES Conference, Rotorua, New Zealand, 10th-13th February 2015.

Burgman, M. 2005. Risks and Decisions for Conservation and Environmental Management, Cambridge University Press ISBN 0521835348.

Burgman, M., Forest, B., Batstone, C., Hopkins, G., Baumgartner, J., and McBride, M., 2011, Getting the best out of experts, International Society for Conservation Biology Conference workshop, University of Auckland, December, 2011.

Hajkowicz, S., Spencer, R., Higgins, A., Marinonic, O. 2008. Evaluating Water Quality Investments Using Cost- Utility Analysis, Journal of Environmental Management, Volume 88, Issue 4, September 2008, Pages 1601–1610

Jorgensen, Bradley S., and Richard C. Stedman. "Sense of place as an attitude: Lakeshore owners’ attitudes toward their properties." Journal of environmental psychology 21.3 (2001): 233-248.

Kahneman, Daniel, and Robert Sugden2005   "Experienced utility as a standard of policy evaluation." Environmental and Resource economics 32.1 (2005): 161-181.

Kerr, Geoffrey N., and Basil MH Sharp. 2003 Community mitigation preferences: a choice modelling study of Auckland streams. Lincoln University. Agribusiness and Economics Research Unit., 2003.

Moores, J.; Harper, S.; Batstone, C.; Semadeni-Davies, A.; Gadd, J; Green, M. 2012. Development of a Spatial Decision Support System for Evaluating the Impacts of Urban

Development on Waterbodies: Building and Testing the Pilot System. NIWA report AKL-2012-038 prepared under contract C01X0908 funded by the Ministry of Business, Innovation and Employment.

Moores, J., Batstone, C., Gadd, J., Green, M., Harper, S., Semadeni-Davies, A. and Storey, R. 2014, Evaluating the Sustainability of Urban Development in New Zealand in Relation to Effects on Water Bodies. The International Journal of Sustainability. Volume Issue 4 pp31-47

Murray, C (2013). An assessment of cost benefit analysis approaches to mangrove management. Auckland Council technical report, TR2013/006.

Nardo, Michela, Michaela Saisana, Andrea Saltelli, Stefano Tarantola, Anders Hoffman, and Enrico Giovannini. 2005. Handbook on Constructing Composite Indicators: Methodology and User Guide. Paris: OECD. Accessed 14 January 2014. http://search.oecd.org/officialdocuments/displaydocumentpdf/?doclanguage=en&cote=std/doc(2005)3.

Sen, A, 2008, Capability and Wellbeing, Chapter Fifteen in Hausmann D. (Ed), 2008 The Philosophy of Economics An Anthology Third Edition University of Wisconsin–Madison, Cambridge University Press.

Van Houten, G., Powers, J., and Pattanakak, S.K., 2007. Valuing water quality improvements in the United States using meta-analysis: is the glass half empty or half full for national policy analysis? Resource and Energy Economics (29): 206-228

Wellington City Council (2014) Water Sensitive Urban Design: A Guide for WSUD Stormwater Management in Wellington

Welsch, H. and Ferreira, S. 2014a. Environment, Well-Being, and Experienced Preference. Vol. 367. No. 14. Oldenburg Discussion Papers in Economics.

Welsch, H. and Ferreira, S. 2014b. Environment, Well-Being, and Experienced Preference International Review of Environmental and Resource Economics, 2013, 7: 205–239.